


Changes in patterns and practices of wheat farming
since the introduction of the ^{new} high yielding varieties.
A study in six villages of the Bulandshahr district,
Uttar Pradesh, northern India, ~~1965-66 to 1971-72.~~

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Thesis submitted for the degree of
Doctor of Philosophy in Geography

School of Oriental and African Studies,
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January 1975.



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Abstract.

Fear of continuing food shortage in India has stimulated efforts to increase agricultural output, and in recent years much research has been directed towards raising returns per unit area of land. Dwarf, high yielding varieties of wheat, rice, maize and millet introduced to India in the 1960s are capable of at least doubling the yields of their indigenous counterparts, and in addition, the shorter maturation period required by the new varieties potentially increases the number of crops that can be harvested each year. Theoretically, these plants could contribute much towards raising agricultural output, but only if their environmental needs are met, as high yields depend heavily on large and frequent applications of water, fertilizer, insecticide and pesticide.

In the agricultural district of Bulandshahr in western Uttar Pradesh, by 1972, new varieties of wheat in particular, had been widely adopted, but the level of their success was unknown. A study limited to six villages was conducted in central Bulandshahr in 1972, with the aim of assessing how successfully farmers were growing dwarf wheat. Data were collected mainly by questionnaire and as areal patterns showed that the adoption of new wheat was almost complete in the study area, the next step was to see whether new farming methods had been similarly adopted. Essential cultivation techniques were examined to see if they had changed significantly from traditional methods, but the best measure of success in farming dwarf wheat is the yield, so information

on crop returns was collected and the relationships of such returns with farming techniques examined. As all results showed considerable variation, the cultivators were classified, for example, according to their caste, farm size or education level, in an attempt to identify any factors which may have influenced their farming practices.

The success of the high yielding varieties rests not only on the cultivators' enthusiasm, but also on a continued supply of essential inputs. Both field work and secondary sources showed the growing difficulties of obtaining adequate inputs, a trend unlikely to change rapidly, and which, if it continued, could reverse the initial success which attended the raising of dwarf varieties.

Acknowledgements

I should like to thank all those who directly or indirectly have helped in the preparation of this thesis, in particular, the Social Science Research Council for financing the Wheat Study, Dr.J.A.Allan who has supervised the work since its commencement in 1972, and, in his absence Mr.R.W.Bradnock and Mr.P.A.Stott for all their help.

I enjoyed my stay in India very much and this was mainly due to the kindness that met me on every side. I should especially like to thank Dr.H.N.Beri and his family with whom I stayed for almost a year in Bulandshahr, and Dr.C.P.Singh of the Delhi School of Economics who gave me considerable support, particularly during the field work. In addition I should like to express my appreciation to all the local government officials for their help, and the numerous farmers involved in the study, for their patience and co-operation. Without the assistance and kindness of these people the field work for the Wheat Study would not have been possible.

Finally, I should like to thank Mr.Keith Ferry for his assistance with computation in the early stages of data processing, Miss Fiona Thomson for her photographic expertise in the reproduction of maps and diagrams, and also my parents for typing the thesis, and more especially for their constant moral support over the past three years.

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List of Abbreviations.

| | |
|--------|--|
| AID | Agency for International Development. |
| BDO | Block Development Office/Officer. |
| ERTS | Earth Resources Transmission Satellite. |
| FAO | Food and Agricultural Organization. |
| HYVP | High Yielding Varieties Programme. |
| IAAP | Intensive Agricultural Areas Programme. |
| IADP | Intensive Agricultural Development Programme. |
| IARI | Indian Agricultural Research Institute. |
| IARS | Indian Agricultural Research Statistics. |
| IBRD | International Bank for Reconstruction and Development. |
| ICAR | Indian Council for Agricultural Research. |
| IMF | International Monetary Fund. |
| NCAER | National Council for Applied Economic Research. |
| NCDC | National Co-operative Development Corporation. |
| PEO | Planning Evaluation Organization. |
| SFDA | Small Farmers Development Agency. |
| SOASUL | School of Oriental and African Studies, University of London. |
| N | North. |
| S | South. |
| E | East. |
| W | West. |
| H.P. | Himachal Pradesh. |
| M.P. | Madhya Pradesh. |
| U.P. | Uttar Pradesh. |

| | |
|--------|---------------------|
| Ag. | Agriculture. |
| Anon. | Anonymous. |
| Ch. | Chapter. |
| Dept. | Department. |
| Dev. | Development. |
| Div. | Division. |
| Econ. | Economic. |
| Geog. | Geography. |
| Govt. | Government. |
| Lab. | Laboratory. |
| Min. | Ministry. |
| No. | Number. |
| Univ. | University. |
| Vol. | Volume. |
| | |
| cm. | centimetre. |
| sq.cm. | square centimetres, |
| m | metre. |
| sq.m. | square metre. |
| km. | kilometre. |
| sq.km. | square kilometre. |
| ha. | hectare. |
| kg. | kilogram. |
| lb. | pound. |
| in. | inch. |
| ml. | mile. |
| Q. | Quintal |
| Rs. | Rupees. |
| % | Percent. |

| | |
|------------------------|---|
| AAAG. | Annals of the Association of American Geographers. |
| Cereal Sci. Today | Cereal Science Today. |
| Econ. and Polit. Wkly. | Economic and Political Weekly. |
| Econ. Geog. | Economic Geography. |
| Exptl. Ag. | Experimental Agriculture. |
| Far E. Econ. Rev. | Far East Economic Review. |
| Foreign Ag. | Foreign Agriculture. |
| Geog. J. | Geographical Journal. |
| Geog. Mag. | Geographical Magazine. |
| Geog. Rev. | Geographical Review. |
| Ind. Fmg. | Indian Farming. |
| Ind. J. Ag. Econ. | Indian Journal of Agricultural Economics. |
| Ind. J. Ag. Sci. | Indian Journal of Agricultural Science. |
| Ind. J. Agron. | Indian Journal of Agronomy. |
| J. Dev. Studies. | Journal of Development Studies. |
| J. Ecology. | Journal of Ecology. |
| J. Sci. Ind. Res. | Journal of Scientific Industrial Research. |
| J. Sed. Pet. | Journal of Sedimentary Petrology. |
| Mod. Asian Studies. | Modern Asian Studies. |
| New Sci. | New Scientist. |
| Prog. Fmg. | Progressive Farming. |
| S. Asian Rev. | South Asian Review. |
| Sci. and Culture. | Science and Culture. |
| Trans IBG. | Transactions of the Institute of British Geographers. |

Glossary of vernacular terms used frequently in the text.

| | |
|---------|--|
| Atta | Wheat flour. |
| Bajra | Species of pearl millet - <u>Pennisetum typhoideum</u> . |
| Bhanger | Older fluvial deposits usually situated on higher ground above flood level. |
| Bhur | Sandy soil. |
| Bigha | Area measure, varying from region to region, equivalent to five-eighths of an acre in the study area. |
| Chak | Block of units of similar productivity, grouped together as 'circles' for purposes of administration. |
| Chapati | Unleavened bread, staple diet in the major wheat growing areas of India. |
| Chhitta | Official lists of land ownership compiled for each village by the <u>lekhpal</u> . |
| Crore | Ten millions. |
| Deshi | Indigenous. In the context of this thesis, <u>deshi</u> usually implies <u>deshi</u> wheat, i.e. indigenous varieties of wheat. |
| Doab | Land between two rivers which meet at some point. |
| Jati | Social grouping within a caste. |
| Jhil | Shallow depression in the surface of the land which fills with rain water during the monsoon, and is used for irrigation purposes. |
| Jowar | Species of millet - <u>Sorghum bicolor</u> . |
| Katcha | Unfinished, made of rough material, temporary. |
| Kanker | Calcareous rubble, plentiful in areas of alkaline soil. |
| Khader | Newer deposits of flood plain adjacent to river bank, and cultivated in the rabi. |
| Kharif | Autumn harvest, the crops are sown with the rains and harvested from September to November. |
| Khasra | Official field book, index compiled at the time of village survey for the census. |
| Lekhpal | Village record keeper, accountant. Previously known as <u>patwari</u> , held the lowest rank in British revenue administration. |

| | |
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| Loo | Very hot dust laden wind which blows from the desert areas of Rajasthan, often for several days at a time. March until the monsoon. |
| Nadi | River. |
| Pradhan | Village headman. |
| Pukka | Complete, made of good material, permanent. |
| Rabi | Spring harvest, the crops are sown after the <u>kharif</u> harvest, in October - November - December, and harvested in March and April. |
| Rai | <u>Brassica juncea</u> - commonly known as mustard. |
| Reh | Saline efflorescence, crystallized in the dry season on the surface and in the upper horizons of salt - affected soils. |
| Tacquavi | Official loans to cultivators from public funds reserved for agricultural purposes. |
| Tehsil | Administrative sub-division in a district. |
| Thoria | One of three types developed from <u>Brassica campestris</u> - commonly known as rape. |
| Usar | Unproductive soil containing saline and alkaline compounds sufficient to inhibit the growth of crop plants. |
| Zaid | Early summer harvest, the crops are sown after the <u>rabi</u> harvest in March-April, and harvested in June-July. |
| Zamindar | Dominant member of local society, appointed as local revenue official under Moghul administration, defined as proprietor under British rule. |
| Zamindari | The rights of a zamindar. Zamindar were abolished under the Zamindari Abolition Act, 1952. |
| Zila | District. (Moghul revenue term). |

Definitions based on Glossary in Whitcombe, E., 1971, Agrarian Conditions in North India, Delhi, pp.297 - 302.

".... whoever could make two ears of corn, or two blades of grass to grow upon a spot of ground where only one grew before; would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together.... "

Gulliver's Travels, by Jonathan Swift.

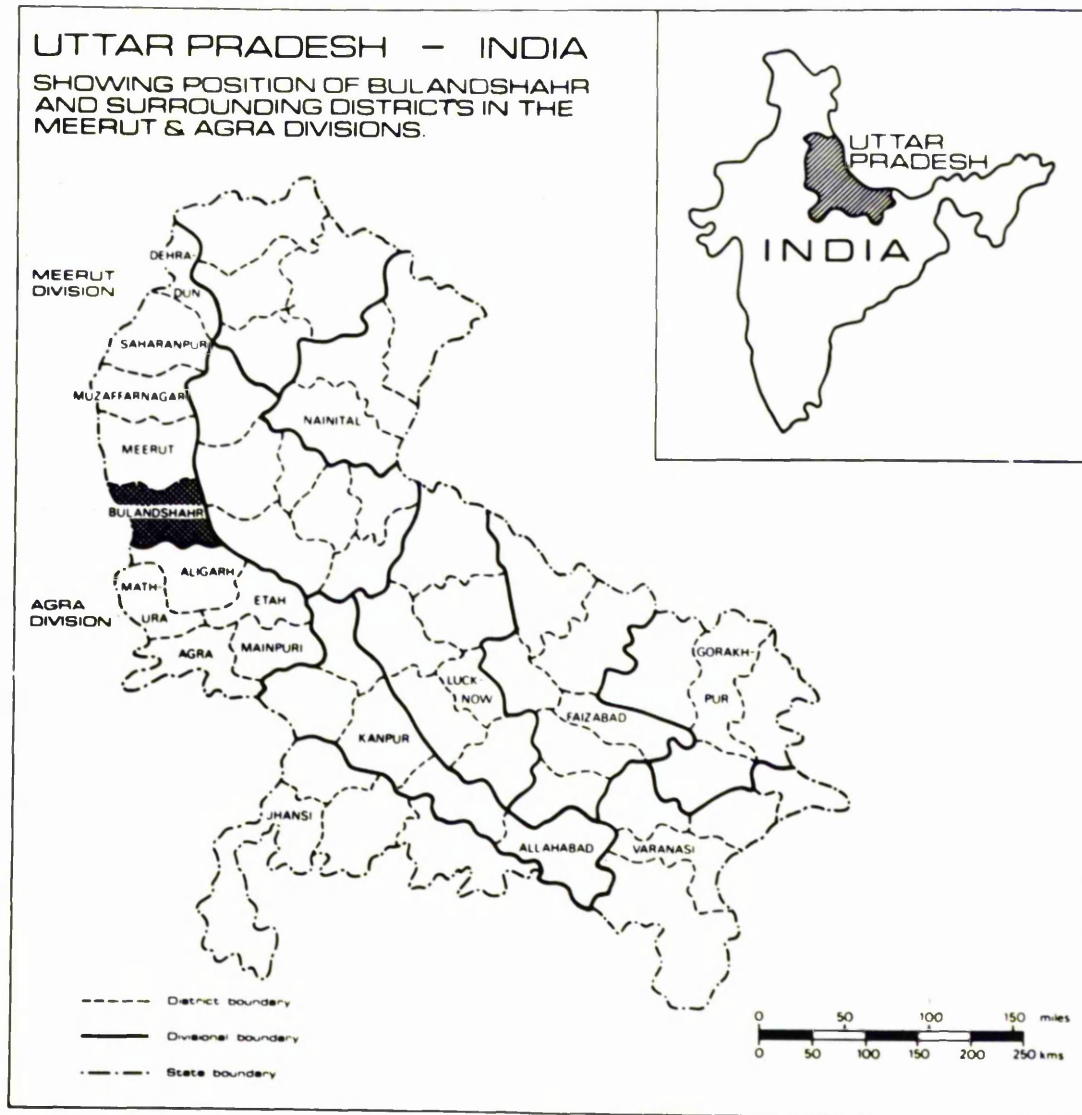


Fig.1.1

CHAPTER 1.

INTRODUCTION

1.1. The study area and the subject of the study.

Traditional farming has been greatly modified in parts of India since the introduction of new high yielding crop varieties. New dwarf varieties of wheat first became available in 1965-66 after a series of poor harvests, and since then the wheat growing lands of north-west India have attracted much interest and study as wheat has shown considerable widespread improvement in yield and especially in production during this period. The extensive adoption of the new varieties of seed has been partly responsible for these changes. Despite the bulk of published material, (1,2,3,4), especially regarding the extent and rate of adoption of high yielding variety seeds, relatively little attention has been given to the extent to which new seeds were being raised in optimum growing conditions or according to recommended practices. This study set out to examine these aspects in some detail and further to attempt to determine which physical and socio-economic variables have affected most significantly the rate and extent of adoption.

The study was carried out in six villages in Bulandshahr district situated in the western plains of Uttar Pradesh(Fig.1.1). Six villages were chosen in order to compare wheat raising in a variety of growing conditions and by a number of village communities composed of different castes with access to a range of irrigation facilities and other inputs. It was felt to be essential that data be obtained from more than one village, despite the inevitable sacrifice in depth, and especially in

the light of the very significant 'between village' variation evidenced in another Bulandshahr study.¹ The study was limited to six villages as the field work involved for such a project was consistent with the resources available.

I envisaged this wheat study as part of a large field study carried out by Allan and Singh during the rabi season 1971-72.² The findings of the District Study have been helpful in providing a setting for this more limited study, which in turn provides supplementary material on specific aspects of wheat cultivation practices. Since the study villages visited in connection with this thesis were different from those enumerated for the main District Study, and because for practical reasons they were located in a small area in central Bulandshahr District, the results of this study stand on their own and are treated as such in the following chapters. Further, they are concerned with aspects complementary to the District Study.

1. Allan, J.A. and Rosing, K.E. 1972, Unpublished processed data of Bulandshahr District Study.

2. The main District Study (Allan and Singh 1972) examined the patterns of innovation of all the new high yielding varieties of wheat, maize, rice and the millets, at district level. Wheat was the most widely grown crop in Bulandshahr (Chapter 3, p.101), and as the results of the District Study showed that the adoption levels of the new wheat varieties were high, a small scale study devoted solely to wheat farming appeared to be relevant. A minor study such as this would benefit from the background information on the district collected in the main study, and on a much smaller scale it would provide a useful supplement to the major study by examining in detail the farming techniques, the advantages and the problems of the new wheat cultivation which confronted the farmer. Since it will be necessary from time to time to refer to the main district study, for convenience it will be referred to as the District Study to distinguish it from the subject of this thesis which will be referred to as the Wheat Study.

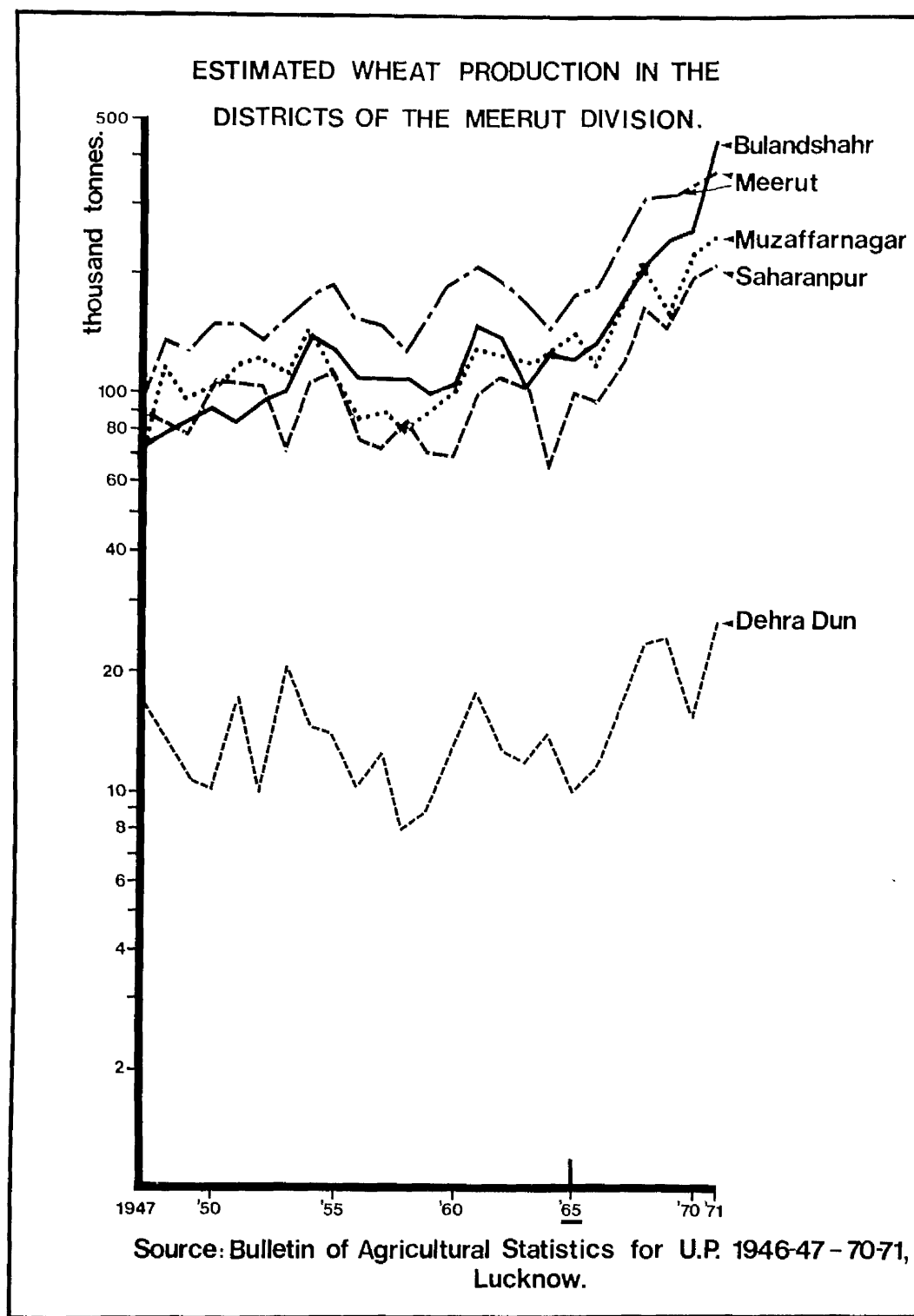


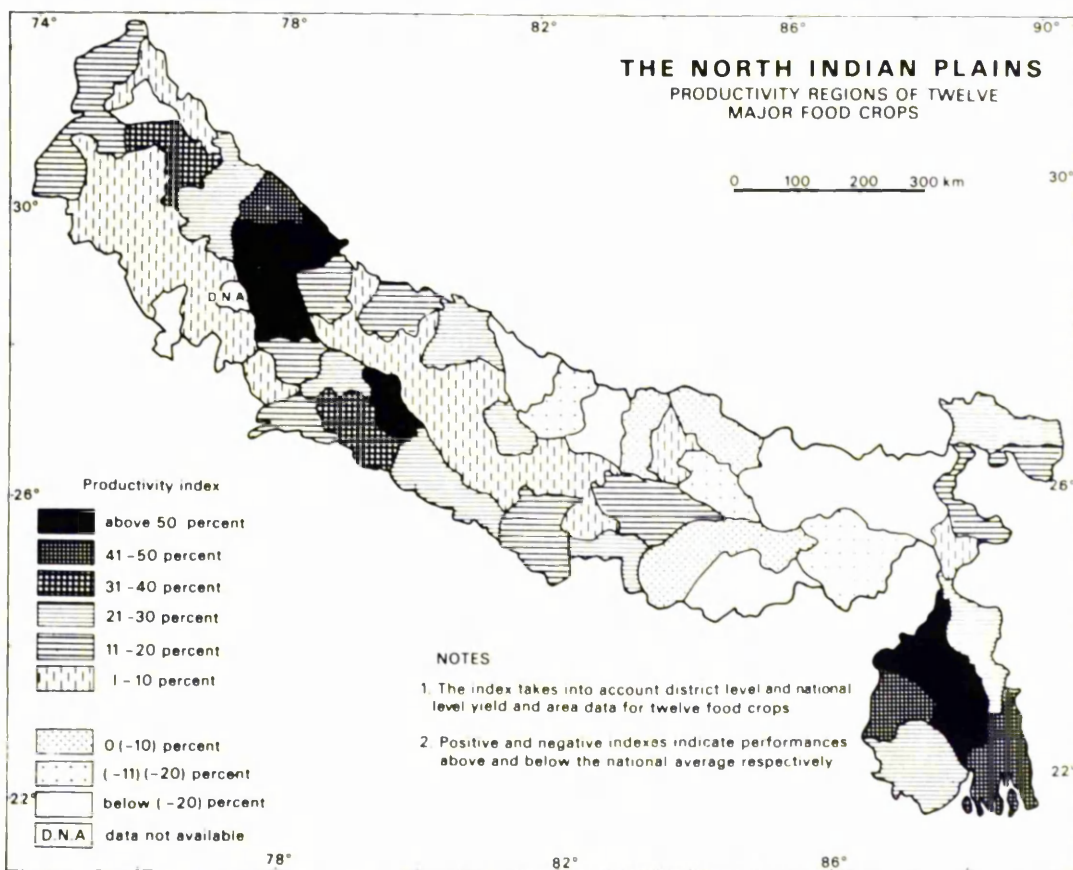
Fig. 1. 2

It is because wheat has been the most widely adopted of the five new high yielding crop varieties released since 1966, that a wheat growing area has been selected for the study. Wheat is of great importance to the majority of dwellers in the north-west Indian plains as it forms their staple diet. Wheat is the major crop of the Bulandshahr district, and according to Mr.B.B.Lal, the acting Block Development Officer, Bulandshahr, is the major wheat 'exporting' district of Uttar Pradesh. A study of wheat farming in Bulandshahr therefore involves both the most important subsistence and cash crop and deals with features central to the economy of the region. The varieties of wheat capable of producing high yields have very different environmental requirements from the indigenous varieties (5), and the main aim of the Wheat Study was to examine the changes that have taken place in selected wheat farming patterns as a result of the introduction of the new high yielding varieties.

Bulandshahr was a suitable district for study, as by 1971 it had become the main wheat producing district of the Ganga-Jumna doab¹. Fig.1.2 shows the estimated wheat production in relation to its neighbouring districts of the Meerut and Agra divisions. This area has great agricultural potential and lies between two extremes; at one extreme in the north west there is comparative affluence in the rural areas of the Punjab (6) while at the other there is poverty in the eastern districts of Uttar Pradesh.

1. The doab is the land between two rivers.

Underlined vernacular terms are listed in the Glossary.



After: Shaf. M Measurement of agricultural productivity in The Geographer, Aligarh, vol XIX 1972 pp 11 & 12

Fig.1.3

Much research has been concentrated in these areas, especially in the Punjab (7,8), with undue emphasis being given to the achievements of the Ludhiana district. Bulandshahr, however, has received much less attention than the neighbouring Aligarh district, which, like Ludhiana is involved in the Government's Intensive Agricultural Development Programme. The doab as a whole has received considerable attention in terms of engineering works and agricultural study because of its alluvial soils, and also because of the Ganga and other canal systems, which since 1857 have provided part of the doab with at least a partial safeguard against the effects of drought. At district level, on the other hand, Bulandshahr itself has not been re-examined or described as thoroughly since the publication of the District Gazetteer of 1903 (9). In 1971 the Punjab National Bank assembled numerous statistics on Bulandshahr (10), but most of these were based on published annual government statistics, and were not the result of field work specifically conducted for a study of the district. Shafi (1972)(11), calculated a 'productivity index' for the north Indian plains. By dividing the sum of the yields of 12 major food crops by the total area they covered, Shafi concluded that Muzaffarnagar, Meerut and Bulandshahr, three of the districts of the Ganga-Jumna doab are among the most highly productive in the north Indian plains. (Fig.1.3). Neither the quality nor the quantity of descriptive material on Bulandshahr in recent years has equalled that included in the District Gazetteer of 1903.

The centre of Bulandshahr district is only 70 km. to the south east of Delhi, and although sufficiently far from the capital to remain a predominantly rural district with nearly

87 per cent of its population of approximately two millions dependent on agriculture (12), it has not been isolated from new farming techniques. It is relatively close to the Indian Agricultural Research Institute in Delhi, and also to Aligarh which has long been part of the Government's plan for improving agricultural conditions. It is only in recent years that Government extension workers have been concentrating their efforts in Bulandshahr as part of the High Yielding Varieties Programme (13). Bulandshahr has been an official member of this scheme since 1970, the purpose of which is to expand the area sown with the new high yielding varieties and so increase crop production. Field work showed that by the rabi¹ season of 1971-72, much of the district was still 'untouched' by the effects of extension workers, and the district seemed an ideal one in which to examine the reactions of the cultivators to the new varieties and their associated farming techniques. The farmers were unaccustomed to answering questionnaires and seemed more likely to provide correct information rather than the information they thought we should like to hear.

1.1.i. Selection of the sample villages and farmers.

The District Study(1971-72) showed that all the new high yielding crop varieties of maize, rice, wheat, jowar and bajra² were grown in Bulandshahr district, but none to the same extent as wheat (14). Resources were limited and so the scope of the study was restricted to the changing patterns of wheat farming

1. rabi season, extends from October to April.

2. jowar and bajra, the millets.

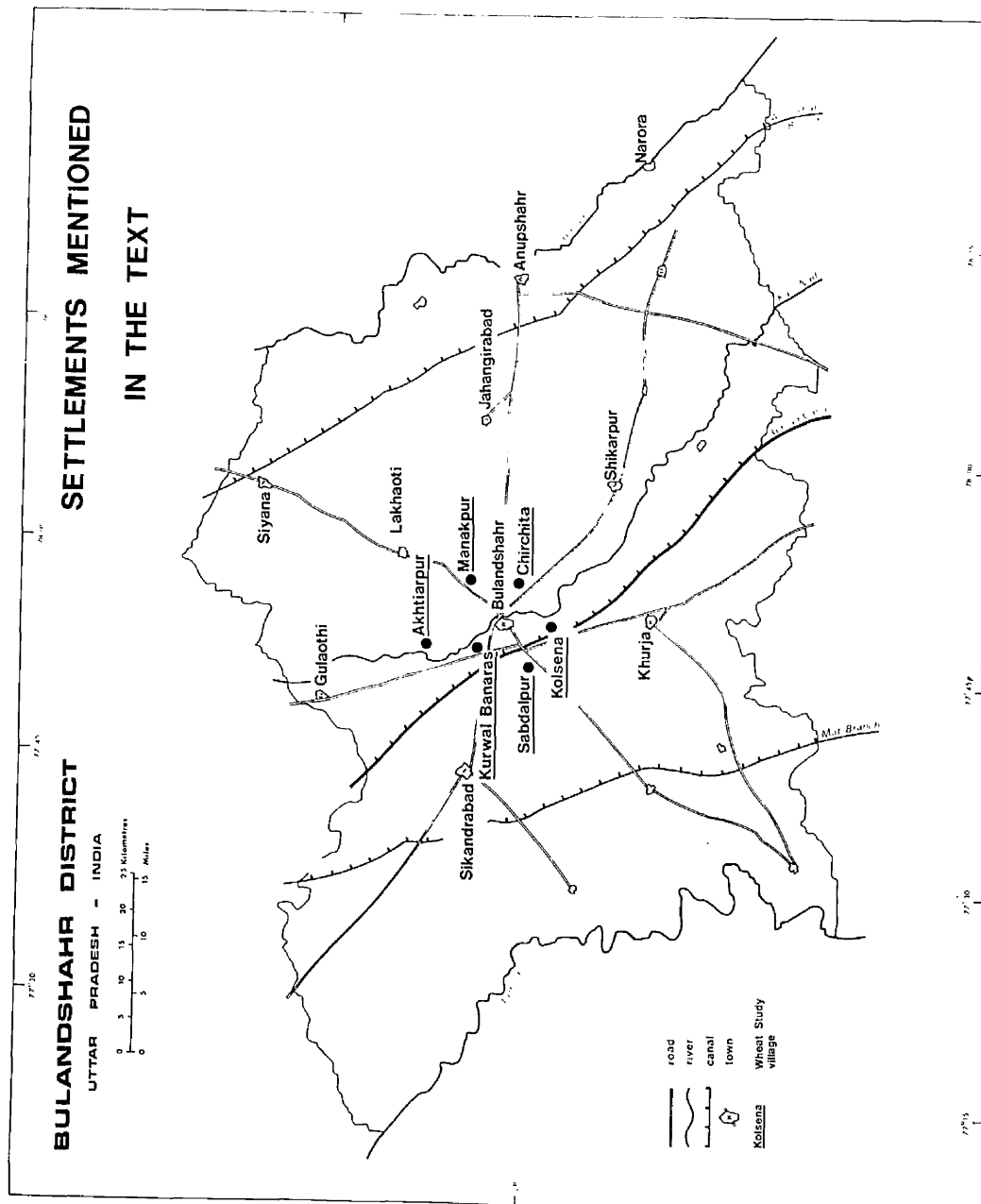


Fig.1.4

in six villages of the district. All these villages were selected from Bulandshahr tehsil¹ and Bulandshahr Block Development Area, as the headquarters of these administrative divisions were located in the district town and so were easily accessible for any necessary information. The villages were all within a 16 km. radius of Bulandshahr so that a small enumeration team could reach a village by bicycle and carry out the enumeration in one day (Appendix 2.1 p.433). As bicycles were the only form of transport available for the enumerators, the settlements had to be within easy reach of the district town where the study was centred (Fig.1.4).

The six selected villages seemed suitable for the study as superficially they showed few differences from the numerous settlements visited during the field work for the District Study 1971-72 (15). Each village did have an atmosphere of its own which expressed itself clearly during enumeration, but they also possessed many common features of a more tangible nature. Every settlement was nucleated, the majority of houses were katcha², and all depended heavily on agriculture for their existence. None of the villages had to rely entirely on open well water as three had access to canal water, and three to tube wells. Although electricity was present in or near the villages for tube wells and pumping sets, only one village received electricity for domestic purposes. Each village had a pradhan³, and as always, the community consisted of numerous joint family groups.

1. Tehsil - an administrative sub division in a district.

2. Katcha - mud and cow dung impermanent structures.

3. Pradhan - village head man.



Plate 1.

A view typical of a Wheat Study village.

Source: Field work for the Wheat Study - March 1972.



Plate 2.

Two farmers who participated in the Wheat Study.



Plate 3.

A Wheat Study enumerator setting out for the field work with soil sampling equipment.

Source: Field work for the Wheat Study - March 1972

Every village visited in the district showed a combination of most or all of these features. It is not claimed that the six sample villages were statistically representative of the district, but all personal qualms about representation were eased during the course of enumeration when the validity of the pilot study undertaken for the Wheat Study was confirmed, and extreme cases were shown to be absent.

30-35 farmers were selected from each village for the enumeration and in all 196 farmers participated in the study. The variation in farm size seemed considerable from earlier experience in the field, and initially an attempt was made to sample farmers randomly from within stratified farm size groups. The lists of farmers to be enumerated were compiled from the village lekhpals's¹ chhitta's². The information from these records however, proved to be incorrect. Farmers usually cultivated considerably larger areas than official records indicated, and so the stratifications of the random sample compiled from the chhittas had no significance in the field. Details of the sampling methods used for the selection of both villages and farmers are discussed in Appendix 1.3 and 1.4 (pp. 427 and 429).

Several hypotheses formulated during preliminary field work formed the conceptual basis of the questionnaire (Appendix 2.1.p 435). These related entirely to changes in wheat farming patterns. In order to put the Wheat Study in its perspective, the history and development of the new wheat will be considered next.

1. Lekhpal - village record keeper, accountant.

2. Chhitta - Official lists of land ownership compiled for each village by the Lekhpal.

1.2. The history and development of the new high yielding varieties of seed.

The 'green revolution' is said to have been precipitated by the development of new high yielding varieties of seed (16). In this section the achievements of plant geneticists in the production of these new varieties will be considered together with the techniques that have been used to develop and spread the new seeds throughout India. Rice, wheat, maize and the millets are the crops grown in India which have benefitted most of all by genetic modification. Plant geneticists have been producing 'improved varieties' since the late nineteenth century (17,18), and so have gradually been raising the yields of food crops. Increasing population pressure has spurred those engaged in such projects and great importance has been attached to them, as according to Brown (1970), in India, 'the stork was beginning to outrun the plough'(19). Although plant geneticists in India have made considerable progress, the major developments in wheat breeding have come from countries outside India, in particular the Philippines, Taiwan, Mexico and Central America.

In the case of rice and wheat, genes for dwarfness have been crossed with high yielding characteristics, and the yield potential of these 'new varieties' is immense (20). In 1964-65 the Taiwanese dwarf variety of rice Taichung (Native)-1 was sown in India on a purely experimental basis and the yields of 87.79 quintals of unmilled rice per hectare was about eight times as great as customary rice yields (21). Similarly, the earliest performance of the new high yielding varieties of dwarf wheat originally introduced from Mexico in 1963, showed that they were

capable of doubling the potential yields of the traditional varieties (22).

The yield capabilities of maize have been improving since 1957 when the Indian Council of Agricultural Research (ICAR), formulated an India-wide improvement programme (23). It was realised that the genetic variability of maize in India, unlike wheat (24), was limited, and so germ plasm from the Caribbean area, Central America and Mexico was brought to India, and in addition to greater yields, the resulting hybrids are more resistant to disease and insect pests than were the indigenous varieties (25).

The millets, jowar and bajra are the other crops which have been genetically modified and, as with maize, notable progress on the plant breeding front took place after 1965 when the first all India co-ordinated programme for the improvement of the millets was held. The genetic variability in the millets is vast, and in contrast to wheat, rice and maize, India has become the chief dispenser of millet germ plasm to the rest of the world (26).

Wheat however, is by far the most important crop in the study area as it is the staple diet of the rural population. The significance of wheat farming in Bulandshahr district is outlined in Chapter 3 (p. 101) and as the purpose of the thesis is to examine recent changes in wheat farming, the history of the development of the new dwarf varieties of wheat will be examined more thoroughly than the other crops of rice, maize and the millets. Among the first wheats which the Rockefeller Foundation supplied

from Mexico in 1963 were four main crosses. One was a line known as 'number 8156', a simple cross which had been multiplied and refined in succeeding generations (27). From this one cross, number 8156, has come the whole family of wheats which now occupies a very great area in Asia. In India it is called 'Kalyansona', (golden saviour), in West Pakistan the same wheat is called 'Mexipak', in Turkey it is called 'Espigas' (spikes), and in addition, both the amber and red strains of the same wheat are still grown in Mexico (28).

The other three high yielding varieties of importance in India also came in a shipment from Mexico in 1963. After being sent to India, the parent material was discarded in Mexico, either because the varieties had not been successfully grown there, or because their merits had somehow been overlooked. These three varieties were developed in India to Sonalika, Lerma Rojo and Sonora 64, and still contribute towards southern Asia's grain production. 'Sonalika' (gold like) is the strongest competitor of Kalyansona, but when farmed correctly Sonalika has larger kernels and matures earlier than Kalyansona. Almost 57 per cent of the farmers sowed Sonalika while only 21 per cent grew Kalyansona according to the findings of the District Study in rabi 1971-72 (29). Lerma Rojo, another of the original red Mexican wheats from which the amber grained Safed Lerma has been derived (30), and Sonora 64, now developed to the amber variety Sharbati Sonora (31), are the other varieties which narrowly escaped being lost. The last two varieties, the hybrids of Lerma Rojo and Sonora 64 are far less popular now in Bulandshahr district, than Kalyansona and Sonalika. These were grown by

Plate 4.

Triple gene Hira,
approximately 80 cm.
high.



Plate 5.

Kalyansona,
approximately
one metre high.



(The soil auger is
one metre long).

Plate 6.



Deshi wheat,
approximately
1.3 metres high.



Plate 7.

Close up of Kalyansona.

Source: Field work for the Wheat Study - March 1972.

11.00 per cent of the wheat growers sampled for the Wheat Study in rabi 1971-72 (Chapter 4, p. 190).

The wheat varieties introduced to India from Mexico were dwarfs in comparison with the Indian indigenous varieties. They were hybrids of the Japanese Norin dwarf wheats which are believed to possess three dwarfing genes which have cumulative effects. Three levels of dwarfing can roughly be distinguished from hybrids of these Norin wheats. These are known as single, double and triple dwarfs. Only the single and double gene varieties were introduced to India from Mexico, and the success of these original varieties has led to the development in India of the triple gene dwarfs such as Hira and Moti. (Fig. 4.23) (32). These are even shorter, but have greater yield potential than the single or double gene varieties, Kalyansona and Sonalika being representatives of the latter. The demand for the triple gene dwarfs is far in excess of supplies of the seed and it is because of this that the proportion of growers of these newest varieties is so low within the study area (Fig. 4.23)

These semi-dwarf varieties of wheat drew the attention of the agriculturalists in the year after their introduction to India as they yielded approximately 35 quintals per hectare, which was four times the then national average of 8.10 quintals per hectare (33). Despite their high grain production there was much about the new wheat that the farmers did not like. The original dwarf varieties imported from Mexico were red in colour and contrasted with the amber grains to which Indian farmers have become accustomed. It is interesting that as little as a century

ago, many of the traditional Indian wheats were also red in colour, but as they did not suit the requirements of the British Flour Milling and Baking Association, amber wheats have been produced and multiplied and have completely replaced the red varieties (34). The traditional Indian wheats are now amber in colour and the red Mexican wheat was rejected by the farmers not only because of lasting prejudice against its 'inferior' colour, but also because of its relatively poor chapati making qualities.

Chapatis are the staple diet of most north Indian wheat farmers, 85-90 per cent of grain consumed is in this form, and so, particular flour making qualities of the wheat are of the utmost importance (35). Some of the important characteristics of chapatis are

"... a creamish colour; soft, smooth, silky
and pliable texture and a sweetish taste."
(36)

To make chapatis of 'good quality' according to the Indian Agricultural Research Institute, the grain must be vitreous and well filled and have a medium protein content of 10-13 per cent. The majority of new high yielding varieties have a protein content within this range, though it is usually towards the upper end of it (37). Other essential qualities include high water absorption power of the atta¹; it should not be less than 68.00 per cent (38), and when mixed, the dough should be pliable and not crumbly so that the surface of the bread is smooth. The nature of the protein and gluten in the wheat largely determines the surface texture of the chapatis.

1. Atta - wholemeal.

Wheat low in protein and gluten is more suitable for cakes and biscuits as it produces a crumbly structure, and conversely, an excessively high gluten and protein content makes the chapati tough and leathery. After chapati dough has been made, it is usually left to rest for about an hour. During this period the diastatic enzymes which have been activated by the moisture, convert the starch to sugars which are responsible for the sweetish taste of chapatis (39). The diastatic activity in doughs made from flour of dwarf or semi-dwarf varieties is according to the Indian Agricultural Research Institute, more than adequate.(40).

Chapatis made from the original types of red wheat imported from Mexico were 'heavy' and did not have a smooth surface like the bread made from traditional amber wheat. These dwarf wheats were crossed with the Indian indigenous varieties in an attempt to combine the characteristics which provided the desired quality of wheat together with high yields. The new hybrids are gaining popularity and with continued breeding experiments they are becoming closer in colour, texture and taste to the indigenous varieties, though there is still a general feeling that chapatis made with modern improved varieties are not as palatable as chapatis made from traditional varieties (41).

At a 'Farmer's Day' organized at the Indian Agricultural Research Institute in Delhi in 1968, the most recent record of such an event, 78 visitors were asked to list their opinions on the colour, taste and general preference for a series of chapatis made from different types of wheat which were unknown

to the visitors. The varieties of wheat under examination were the semi-dwarfs Sonalika, Kalyansona and Sharbati Sonora, and an indigenous improved variety developed in the Punjab, C 306 (42). The majority of the participants in the experiment preferred the colour of the chapatis made from variety C 306, but apart from this, the results of the opinion poll showed that the new high yielding varieties of Sharbati Sonora and Sonalika were comparable or even superior to the improved indigenous variety C 306. Chapatis made from Kalyansona were not so popular and the data from my own Wheat Study have confirmed these results (Fig.4. 23.). Sonalika is the most popular variety and is preferred to Kalyansona for its colour, texture and taste.

In addition to raising the yields of the new high yielding varieties, great effort has also been made by wheat breeders to produce wheat which suits the farmer's taste. The government cannot afford the rejection of the dwarf varieties, as in the further adoption of these seeds lies India's only hope of increasing her food grain output rapidly. Poor harvests of 1962-63 and 1965-66 were the start of India's dependence on American supplies of grain, and although the United States did have surplus grain in those years, the likelihood of a future world food shortage was anticipated and her policy changed towards India from one of virtual charity, to a scheme for helping India to be self-sufficient - at least in terms of food production (43). The spread of the new high yielding varieties appeared to be one method of achieving this. While India continued to depend on imported grain, there was no hope of inducing farmers to grow more for themselves. Contracts for

grain shipments were abruptly reduced to increase the incentive to India to grow more food, and guarantees for supplies were made for the short term only (44). With no long term promise of aid from abroad, Dr. Subramaniam, the Minister for Agriculture in 1966, was forced into devising a policy which encouraged the spread of the new varieties and their associated technology, as this seemed the only hope of raising agricultural production in India at the rate that was necessary. The High Yielding Varieties Programme was created to fulfil this need (45).

While the United States had reduced wheat shipments to India, investment in Indian agriculture was increased through the Agency for International Development (AID). The new high yielding varieties depend heavily on material inputs; fertilizer and water in particular (46). Unfortunately chemical fertilizer manufacturing capacity was relatively undeveloped in India, and so initially, the United States exported chemical fertilizer to India, but gradually changed her policy to one in which investment was made in fertilizer plant, so attempting to reduce India's direct dependence on foreign aid (47). Water was also necessary for the new varieties and so machinery for the construction and maintenance of tube wells was made available to India through the Agency for International Development (48). Farmers were encouraged to use tube wells as these small scale irrigation projects soon increased the returns from the fields. Simultaneously, water resources were being improved on a larger scale, but these involved long term policies and were of little immediate benefit to the cultivator (49). As the need to increase food production became acute, the policy of the Indian government was

to implement the spread of the new high yielding crop varieties through a scheme entitled the High Yielding Varieties Programme (HYVP). The Programme was initiated in 1966 and aimed to terminate dependence on imported grain.

1.3. Policy for the expansion of the area under the new high yielding varieties in India.

The new hybrid seeds can tolerate considerable variation in physical conditions, unlike the indigenous varieties (50), but they are unable to produce their potential yields if they are not supplied with adequate fertilizer and water, and are not given the attention they require. Most of India suffers from periodic and often protracted drought, and in the absence of irrigation facilities only dry farming techniques are possible and these do not suit the new high yielding varieties. Indigenous varieties are preferable in these less favoured areas, until improved seeds, specially bred for these conditions, are available. Because it was clearly wasteful and probably demoralising for farmers in these dry areas to grow the new wheat and other new varieties, the government guided the spread of the 'new technology' to areas where both soil and climate were suitable and where a supply of water, fertilizer, insecticide, pesticide and any other requirements could be relatively assured (51).

The Indian farmer is often said to be hostile to any form of change, and so areas had to be selected where new concepts would be received and new ideas put into practice. In the study area however, it was found that the farmers appeared to be very receptive to the new seeds and were willing to modify their traditional farming techniques (Chapter 6) to suit the physical requirements of the plants. The areas selected for the High Yielding Varieties Programme were the Intensive Agricultural Development Districts. These districts came into being during India's third Five Year Plan during the early sixties (52).

They were selected for their agricultural potential, and the farmers of these districts have gradually become accustomed to new techniques in farming and to the presence of extension workers. The last is probably the most significant factor. In many parts of India which have not been closely involved in agricultural development programmes, farmers are relatively unaware of recent changes in farming and rather than concentrate extension work in these areas, it seemed that the High Yielding Varieties Programme could best be implemented by extending the existing agricultural development policies. Concentration on areas selected for their agricultural potential not only meant that there would be greater participation in the schemes by local cultivators, but also that if agricultural productivity was raised by the use of new, improved, farming techniques, surplus produce could be exported from these areas of plenty to the poorer areas which had not been included in the Programme.

The Intensive Agricultural Development Programme (IADP) was extended by the addition of a second group of districts called Intensive Agricultural Areas and these are part of the Agricultural Areas Programme (IAAP). They were selected in the same way as the districts of the Development Programme and are also considered to be areas capable of high levels of agricultural production if supplied with fertilizer, irrigation water and credit for farm machinery and other necessary inputs(53). Bulandshahr district became part of the Areas Programme in 1970, and so has only recently felt the benefits of concentrated efforts of extension workers. No IAAP statistics had been published by the end of 1972 on the changes in the agricultural situation in

Bulandshahr since its inclusion in the Intensive Agricultural Areas Programme.

Both the IADP and the IAAP districts are included in the High Yielding Varieties Programme and in these areas of favourable physical conditions, farmers are urged to grow the new varieties and are assisted in their efforts by practical demonstrations and guarantees of certain material inputs.

In the extensive campaign to further the spread of the new high yielding varieties, leaflets have been distributed among the farmers urging them to grow the new crop varieties and to follow closely the recommendations of the 'package of practices'. A reproduction of one of the High Yielding Varieties Programme campaign leaflets is included in the Appendix (Appendix 3.2.1. p.464) together with a list of similar leaflets available to the farmer. The leaflets are not restricted to the methods of farming the new crops but even suggest recipes for the new high yielding varieties to popularise them, not only among the farmers but with their families as well.

Unfortunately many farmers are illiterate and derive little benefit from the material, particularly that written in English, as is the leaflet included in the Appendix 3.2.1. p.464. Field work showed that radio broadcasts and films shown at local cinemas were far more likely to reach the farmers than were the television broadcasts restricted for the most part to an urban minority. According to extension workers in the Punjab

and in parts of Uttar Pradesh, television sets are installed in Co-operative and Block Development Offices and can be seen by those few farmers who are aware of the time and place of showing of the programme. The benefits of such relatively sophisticated methods of propaganda, are still of little value in the study area and many of the farmers involved in the study had received no leaflets, neither had they seen nor heard television programmes, films or radio broadcasts but depended entirely on information from the local extension workers or from neighbouring farmers.

Regardless of whether or not the cultivators had been directly affected by the propaganda campaign, they were all well aware of the new high yielding varieties and of their potential benefits. Although material inputs are relatively assured in districts involved in the Programme, such as Bulandshahr, the farmers still complain that they could not grow their new varieties properly because fertilizers were not readily available, nor were the credit facilities they needed so badly. The inability to meet the demands of the farmers must be one of the greatest problems of the government. The campaign for the spread of the new high yielding varieties has continued apace but supplies of inputs are not being maintained at the level of demand. Owing to the shortages of fertilizer the Indian wheat crop is suffering (54) and the inadequacy of electric power production aggravated by recent fuel shortages and high prices (55) has done little to further the development of small scale irrigation, so necessary for the successful farming of the new varieties.

The second generation problems are immense. Now that the farmers are becoming aware of the new high yielding varieties and are learning of their requirements, they are unable to obtain them and a situation can be visualised where the new varieties have been widely adopted and have virtually failed owing to the insufficiency of certain material inputs. The next section of this chapter will examine records of the success of the high yielding varieties in India.

1.4. Assessment of the success of the high yielding varieties.

Published statistics in the annual State Bulletins imply the successes of High Yielding Varieties Programme districts, such as Aligarh, but these data are questionable as one is ever aware that results published by Programme districts are intended to encourage farmers to sow the new seeds. In the State Bulletins of Agricultural Statistics, the main source of information on agricultural conditions, details on the methods of data collection are scant and so limit the extent to which those data may be used as truly representative of the population. Although published statistics may give cause for optimism, official reports of India's Planning Commission, such as the study for the rabi season of 1968-69 are extremely cautious and emphasize the problems and shortages confronting the farmers, particularly in the case of electricity and irrigation supplies (56). It is not surprising that the programme reports are cautious because success is often estimated from such indices as the number of adopters and, on the increase in area sown with the new seeds (57, 58). These data are of limited value because they give no indication of the levels of success which the cultivators are achieving with their new varieties. Yield statistics would be far better indicators, but accurate collection of yield data is difficult and expensive and so material from this source is limited. Some attempt however, is made to collect information of this nature in the Programme districts, and yield estimates are compiled on the basis of approximately 300 crop samples cut from each district (59). According to the officer in charge of field experiments for the High Yielding Varieties Programme in Aligarh, the 300 crop samples covered all the new and hybrid varieties; it was not a case of

300 samples per crop. The samples are cut from villages which have been influenced by extension workers, and so may not be typical of the entire district if the information has not been evenly disseminated. Results are probably higher than the mean for the district as a whole, though this cannot be checked without another 'large' random sample from the whole district. Production figures are obtained by combining the yield and area estimates, and if yield figures are obtained from a small and biased sample, the production figures must bear the same degree of error as well as any incurred in the areal statistics.

The new varieties of wheat have a shorter life cycle than the traditional varieties, and they are much more demanding on the time and effort of the farmer. Their input requirements are much greater than the indigenous varieties, and the timing of the inputs is also of great significance (60). The physical requirements of the new wheat are considered in detail in Chapter 6. The farmer has to do much more than just sow the seed in order to harvest a good crop, and because of this the areal definition of the new high yielding varieties is a poor index of their success. Mere estimation of the production and yield also gives little idea of how well the cultivators are learning to cope with the scientific approach to farming, and if these are replacing traditional methods which have almost become instinctive. The data available in the IADP and High Yielding Varieties Programme reports cover only certain aspects of the changes that farmers are having to make, and certainly do so at no greater depth than district level (61).

The plants are highly responsive to material inputs and so

output must be related to input levels. No attempts are made to link one to the other by government organizations (62). The only occasions when inputs and outputs of the new varieties are related is in experimental work carried out in research establishments, but these results cannot be extrapolated to apply to field conditions where the physical environment and information levels are far from perfect. In districts involved in the Areas Programme, a greater attempt is being made to collect detailed information on the methods farmers are using for growing their new high yielding varieties. A sample of 80-100 villages has been selected in these districts and the farmers answered a detailed questionnaire on their farming techniques. This information according to Dr.S.K.Raheja, the chief statistician at the Institute of Agricultural Research Statistics, Delhi, is for tabulation purposes only and is not used for the prediction of relationships between crop inputs and outputs. Lipton also remarks on the quantity of data which are processed, but which are not used for the explanation of farming patterns (63).

Many of the research topics connected with the new high yielding varieties and the new farming technology have examined patterns of innovations and diffusion over space and through time. These studies do not really reflect the level of success that farmers are achieving with the new varieties and there seemed to be a need to depart from the numerous studies involving spatial relationships at district, state and sub-continental level, and to look at the farmer in greater detail.

CHAPTER 2.

Methodology and scope of the Wheat Study.

2.1. Introduction.

The success of the high yielding varieties is important to India's plans for raising her food production, but success or failure of a crop depends to a very large extent on the decisions of the cultivator. As wheat is the main food crop of Bulandshahr district (Chapter 3. p.105), this study has examined the approach of the farmer to the cultivation of new wheat varieties, and his willingness to modify farming techniques to comply with the demands of 'scientific agriculture'. Without detailed information on the methods of wheat farming, it seemed impossible to estimate the advantages and disadvantages of the new high yielding varieties. A compromise had to be made in the field work, as the need for detailed information at this level meant that the size of the study area had to be restricted to six villages in Bulandshahr district. A detailed questionnaire survey was conducted in these six villages (Appendix 1.2)(Fig.1.4) to test a series of assumptions about wheat farming which have been grouped under a single null hypothesis (Chapter 2.p.59). Before the findings of the questionnaire survey can be discussed, the background to the development of the hypothesis must first be considered so that the reasoning behind the assumptions is clear.

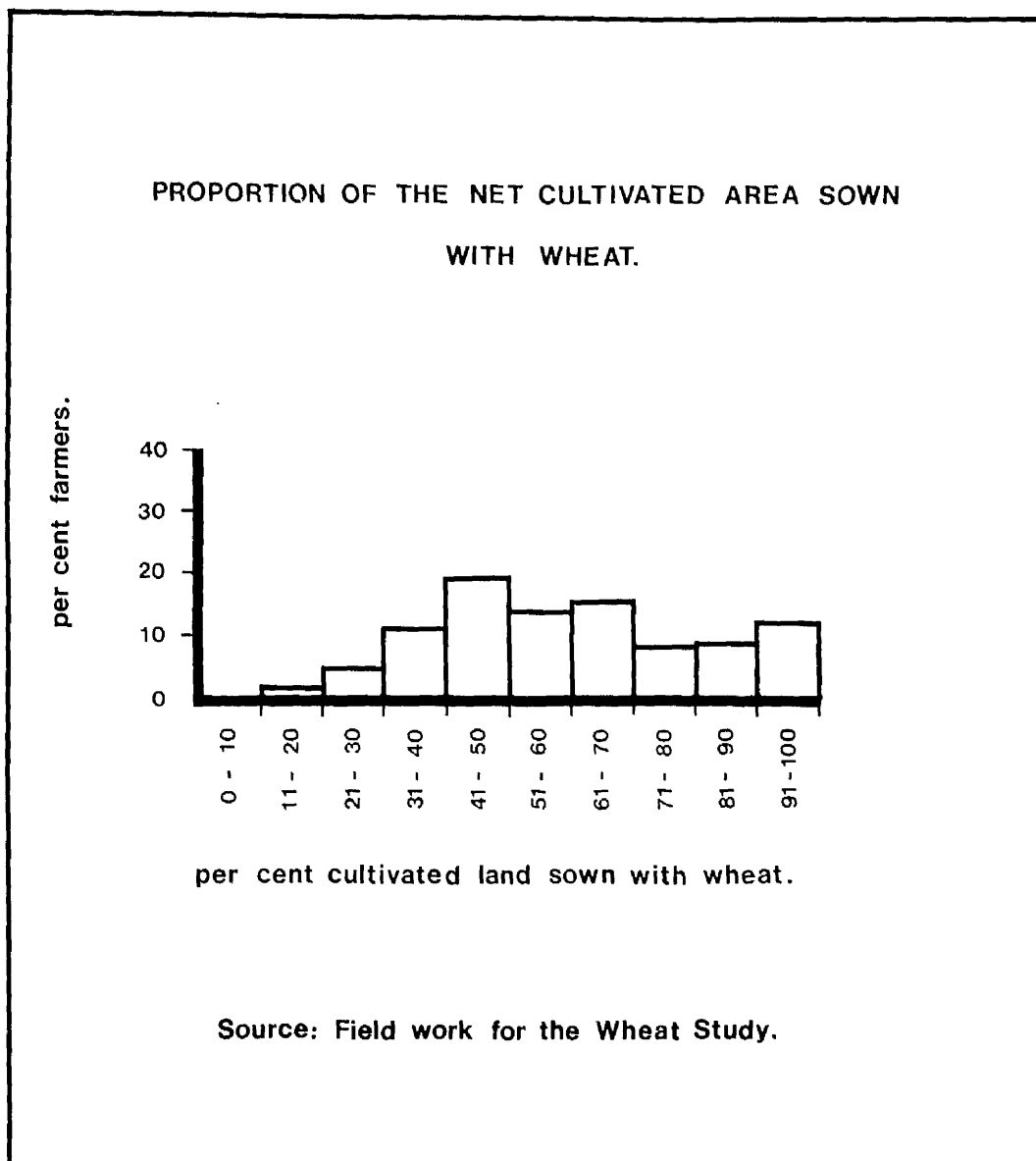


Fig . 2.1

2.2. Background to the development of the major hypothesis.

Field observations that farmers sowed the greater part of their land with wheat were confirmed by the results of the questionnaire survey. Fig.2.1. is a frequency diagram showing the proportion of the net sown area under wheat according to the questionnaire study. The curve is far from 'normal' in its distribution and shows that nearly 60 per cent of the cultivators sowed 41-70 per cent of their holdings with wheat. None sowed wheat on less than ten per cent of his land, but at the other end of the distribution a second rise in the curve indicated that wheat was almost the only rabi crop for 12 per cent of the farmers. Official statistics estimate that 63 per cent of Bulandshahr district is sown with wheat (1), and a comparable statistic of 58 per cent was obtained for the Wheat Study area.

The increasing popularity of the new high yielding varieties is the reason attributed to the rise in area sown to wheat in Bulandshahr district.(Chapter 3,p.105). Nowhere in published statistics does the Ministry of Agriculture differentiate between the new and indigenous varieties, but the acting Block Development Officer of Bulandshahr in 1972, Mr.B.B.Lal, was certain that this rise was due entirely to the growing area under new wheat. Of the sample farmers, 97 per cent had started to grow the new high yielding varieties, while only 24 per cent of the farmers still grew deshi wheat. It was clear both in the field and from the data that the farmers were prepared to experiment with the new varieties. The three sample farmers who grew only deshi wheat all had small farms of 6, 12 and 20 bighas¹ respectively. As

1. 12.35 bighas = 1 hectare.

both new and deshi wheat farmers were represented within the sample, the changes in wheat farming patterns and practices were examined by the following hypothesis.

Major hypothesis to be examined.

The null form of the major hypothesis which emerged from the field work and preliminary analysis of the data claimed that

there has been no significant change in wheat farming patterns in the study area, since the official introduction of the high yielding varieties in 1965-66 .

As this hypothesis is so complex it has been sub-divided into five sections each of which will be examined in detail.

1. There has been no significant change in the number of adopters of the new wheat.
2. There has been no significant change in the area sown to the new wheat varieties.
3. Techniques of new wheat cultivation have not altered significantly from traditional methods.
4. Farming techniques used for the new varieties fall significantly below their environmental demands.
5. Yields harvested by the cultivators in the study area are significantly lower than the potential yields of the new varieties.

~~Where precise numerical data are available, the null hypotheses have been used to test them, but~~ Where data are not of sufficiently high quality to be examined by ^{the null hypothesis} this method, the formal null hypothesis approach was often abandoned in favour of a more informal discussion of the topic. Although not precise, the qualitative field observations were always a valuable addition

to certain arguments illustrated by the numerical data. The purpose of the study however was to obtain precise information about the study area, so as much information as possible was collected in numerical form and these data have contributed directly to the formal discussions in the following chapters. As each section of the major null hypothesis was tested by examining both qualitative and quantitative material, the claims of the major null hypothesis were either rejected or accepted on the basis of these combined results.

2.3. Outline of the main chapters of the thesis.

The assumptions of the null hypothesis are examined fully in Chapters 3 to 7 of the thesis, and the following paragraphs summarise the aims of each chapter and of the study as a whole. Chapter 3 discusses the change in certain aspects of agriculture in Bulandshahr district since the mid-nineteenth century, and so provides some historical and agro-economic background information to the study area. Wheat emerges as the most important crop of the rabi season, and so Chapters 4 and 5 continue at a more detailed level using original material from the field to examine the recent changes which have taken place in wheat farming in the six study villages in Bulandshahr. Farmers in the study area were asked to recall conditions for the rabi seasons between 1969-70 and 1971-72, and in some cases for earlier years, to see whether they had changed their approach to wheat farming as the district statistics in Chapter 3 imply.

While Chapters 4 and 5 examined the first two parts of the major null hypothesis (p.59), Chapter 6 considers the next two sets of claims that the farmers have not modified their traditional farming techniques and are not growing the new high yielding varieties of wheat according to their physical demands (p. 59). The first part considers the relationship between present farming techniques and traditional practices by comparing cultivating methods used for the raising of deshi wheat with the farming practices used for the new varieties. An index is derived which indicates the extent of change from the traditional approach. In the second part, the adequacy of farming techniques is assessed by a comparison of methods used with those suggested by government

agriculturists. Selected farming techniques have been examined by these means to illustrate the degree of change away from traditional farming and towards the new scientific approach which is required by the high yielding varieties.

The conclusions from Chapter 6 involve predictions about the yields farmers should receive as a result of the techniques which they have been using. One would expect the most 'progressive' farmers to have the highest yields, and it is this assumption, stated in part 5 of the major null hypothesis (p.59), that is examined in Chapter 7. At the same time, the major null hypothesis claims that because the farmers are not using the required farming techniques for the new wheat they are not realising the potential of the high yielding varieties. A second questionnaire to discover the yield these same farmers had obtained was completed in June 1972, and using the results of this survey, both the last part of the major null hypothesis and predictions from Chapter 6 are tested in Chapter 7.

An attempt was made to relate selected inputs to outputs on the basis of the formal questionnaire surveys, but the reliability of a single source of information is always questionable, particularly when it involves yields, and in order to check the figures provided through the enumeration of the farmers, crop cutting samples were taken and the additional information was analysed in a similar fashion to the questionnaire data. Crop cutting samples are potentially of great value, but are, however, extremely difficult to collect if data of any high level of accuracy are required. Accuracy may be impaired by inconsistent

data collection and through losses during transport and storage of the material. On account of this the crop cutting samples in this Wheat Study were few as the collection of accurate data which were representative of the study area was the main purpose of this part of the field work. Despite the small size of the crop cutting samples, they have been used in this dissertation and reservations about these data have been fully considered in Appendix ~~p454-6~~. They have provided information at the level of the plot and so are more detailed than the questionnaire results. In addition to being of interest themselves, the crop sample results have helped to verify important sections of the : questionnaire material.

The crop and soil samples were selected from wheat fields belonging to 35 of the 196 farmers. Physiological analysis of the wheat samples provided data on the size and weight of wheat ears and grains, the number of plants per unit area and the protein content of the wheat. This, together with information on the chemical contents of the soil, derived from the field soil samples, were related to questionnaire information on farming techniques provided by the farmers.

According to the officials of the Indian Agricultural Research Institute (IARI), Delhi, the results are of the kind generally used for testing whether or not the inputs of seed, water, fertilizer and pest control, among others are sufficient. In this way the adequacy of the inputs examined in Chapter 6 are re-tested by another means and with the use of different techniques, not solely dependent on the integrity of the farmer.

The introduction of the new high yielding varieties to the farmer, particularly in the areas selected for agricultural development has meant that inputs such as seed, water, fertilizer, insecticide and pesticide must all be accessible if the new varieties are to be grown successfully. Chapter 8 examines the availability of input supplies and credit facilities to the farmer and the extent to which the cultivators prefer government to private sources of material inputs and credit. Most of the information in this section will be qualitative as it has been compiled from discussions with both local government officials and farmers. Quantitative material may be precise, but the impressions one receives from informal discussions can also be of great value, and in the case of Chapter 8 certainly provided much more comprehensive and valuable information than was available from the formal questionnaire survey.

Chapter 9 examines the implications of the changes in wheat farming patterns due to the introduction of the new varieties. Economic and social consequences seem to be the most important, as raising crop production is seen as one means of raising the quantity of food available for consumption by the rural population. The effects of the new technology on the physical environment, particularly on soil conditions, could be significant in the future even if they are not at present, and these effects will also be considered. Finally, the material from these eight chapters will provide the basis of the concluding section, Chapter 10. Having outlined the purpose of the thesis, we shall next consider the methods by which the data have been analysed.

2.4. Methods of analysis of the data.

Nine variables which are either essential or important to wheat farming have been selected, and in this study they are the statistically 'dependent' variables (Fig.2.2), dependent on several 'independent' variables (Fig.2.3). These should indicate whether or not farming methods in use are suitable for the new high yielding wheat varieties. Variation is bound to exist among the farming techniques employed by the cultivators and so a second group of eight variables which could possibly explain some of the variation in the dependent variables has been compiled (Chapter 2 p.66). In this study these will act as statistically independent variables.

The dependent variables.

From field observations, the following list of dependent variables was selected to represent the methods of wheat farming used by a cultivator.

1. Land preparation - number of ploughings.
depth of ploughing.
method of ploughing.
2. Seeding ratio - seed sown per unit area.
3. Planting depth.
4. Date of sowing - method of sowing.
5. Farmers growing early wheat, late wheat, deshi.
6. Irrigation - number of waterings by different sources.
7. Fertilizer - quantity of fertilizer applied per unit area.
types of fertilizer applied.
method of application.

2. Human variables - 5. Year the farmer was instructed in

(Contd). in the new farming techniques.

6. Education level of the farmer.

7. Whether the farmer was an ex-
Zamindar¹ or close relative of one.

8. Size of the area cultivated by
the farmer.

Fig.2.3.

Source: Field work for the Wheat Study - March 1972.

The purpose of selecting these variables was to see if they bore any significant² relationship to the various wheat farming techniques, the dependent variables, which had been examined. It was hoped that possible causal factors might be isolated, though causality is a 'dangerous' word in the statistical sense and is used with proper reservation. The farming methods always act as the 'dependent' variables in the analysis (Fig.2.2), while the group of potentially causative factors listed above constitute the 'independent' variables in the statistical sense (Fig.2.3).

-
1. Zamindar: Dominant member of local society, appointed as local revenue official under Moghul administration, defined as proprietor under British rule.
 2. Significant: Assessments of relationships as 'significant' or 'insignificant' are always based on the results of statistical tests. The level of significance used throughout the thesis is 95 per cent. Any relationships likely to occur less frequently than 95 times in every 100 are considered statistically insignificant, while relationships where the probability of occurrence is greater than 95 per cent are deemed statistically significant.

If causal effects and relationships are to be established, it is essential that any independent variables are unrelated to any other so-called 'independent' variables. Linkages among the causative variables reduce the accuracy with which the strength of relationships between 'independent' and 'dependent' factors can be assessed. Several of the 'independent' variables appeared to be closely related when examined in the field and, from a statistical point of view, this is unfortunate, but in the 'real world' it is difficult to isolate and quantify the effect of a single variable on another, so the relationships between the 'independent' variables will now be examined. The use of the term 'independent' appears to be self contradictory, but independent does always presume statistical rather than absolute independence, the latter being a meaningless term in relation to these variables. For instance, a notable relationship was apparent in the field between the variables 'caste' and 'education level'. When analysing the effect of either 'caste' or 'education level' on any of the statistically dependent variables, such as the quantity of fertilizer used, one cannot decide which of the 'independent' variables is responsible for more of the variation in the dependent: it could be that cultivators who have been educated have a greater understanding of the physical requirements of the new plants, but one could also argue from field observation that the higher the caste of the cultivator, the more likely he is to have been educated, and so 'caste' could be considered the major influential variable. In consequence, it is a problem to assess the precise effect of any of the statistically 'independent' variables on the dependent when they are inter-related. A detailed analysis of the linkages between the 'independents'

will confirm how statistically significant any relationships are (Appendix 4. p.480) and so will be of value when the influence of the 'independent' variables on the 'dependents' are being assessed. Regardless of their inter-connection, some of the 'independent' variables will still be used in the analysis, but with reservation due to the implications of their linkages.

Many of the 'independent' variables are nominally scaled, so the use of high powered statistical techniques for estimating the extent to which 'independent' variables are co-linear, are inapplicable. The chi square test will be used throughout this section merely to establish the presence or absence of relationships. Unfortunately the low level of measurement prevents any further quantification of the strength of existing links between the 'independent' variables. In some cases, such as size of the area farmed, data have been recorded on an interval scale and so could be examined with higher powered statistical tests. In order to maintain a consistent approach to the analysis, the lower powered¹ techniques have been used throughout this section.

-
1. The power of a statistical test is defined as 1- probability of a type II error, and is therefore inversely related to the risk of failing to reject a false hypothesis... The greater the ability of a test to eliminate false hypotheses, the greater is its relative power. The term 'power efficiency' is normally used to refer to the power of a certain test relative to that of its most powerful alternative. If the power efficiency of the Kruskal-Wallis test for example, is 95 per cent, it means that the power of the non-parametric test using 100 cases is the same as the parametric analysis of variance test using 95 cases.

Source: Blalock, H.M. Social Statistics, 1960, London, pp.188-193.

Diagram to show the relationships between potentially causative ('independent') variables.

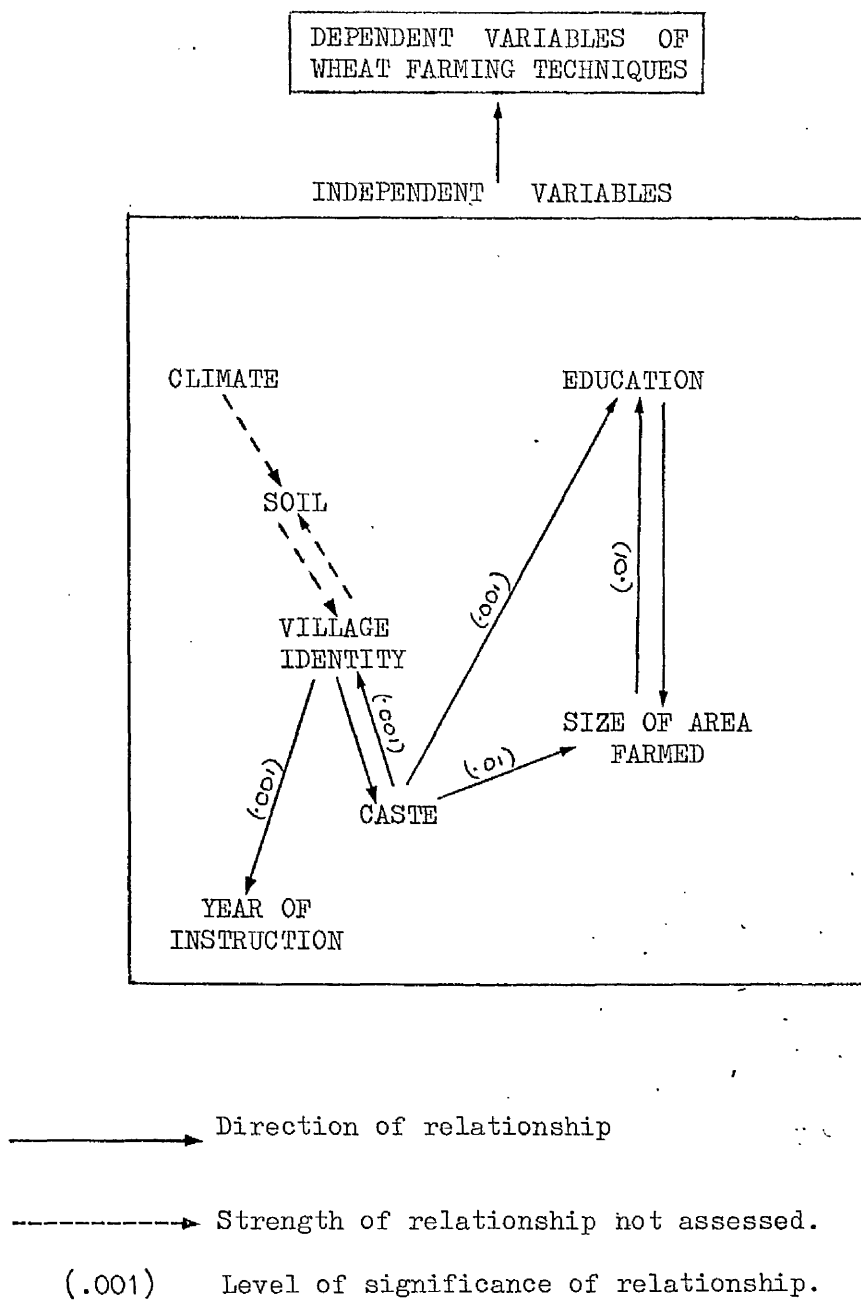


Fig.2.4.

2.4.1. Summary of the relationships between
the independent variables.

A detailed account of the relationships between the independent variables has been included in Appendix 4, pp. 480-490 and as a summary measure Fig.2.4 has been constructed to illustrate the statistically significant relationships which have emerged between these 'independent' variables. The chi square test (2) was used to estimate the presence or absence of significant relationships, and where linkages were in evidence the level at which they were statistically significant has been included in Fig.2.4. The direction of these significant relationships has also been indicated and the reasoning behind these decisions has been recorded in the detailed discussion of the linkages between the 'independent' variables (Appendix 4, pp.480-490).

The effects of climate and soil could not be estimated as climate was presumed to be constant over the study area and analysis of soil samples discussed in Appendix 2.2, pp.452-454 gave no indication of significant variation in soil conditions within the study area.

'Caste' and 'village identity' emerge as two variables with the greatest number of statistically significant links with the other 'independent' variables and as they dictate the direction of the relationship in every case, it is never possible to assess how much of the relationship, for example, between the size of the area farmed and any of the 'dependent' variables (Fig.2.2) results from the indirect effect of caste (Fig.2.4). To give a second example, any relationship between the year of

instruction in new farming techniques and the 'dependent' variables may well be the indirect effect of 'village identity' as these two 'independent' variables are significantly related (Fig.2.4).

Fig.2.4. also implies that any connection between the education level of a farmer and the 'dependent' variables may be partly explained by both his caste and his village identity as this 'independent' factor acts indirectly via caste. As a result of this the precise effect of the level of education of a farmer on his decision making processes cannot be estimated and so the problem of interpretation of results has become increasingly apparent.

In any set of relationships involving human thought and action it is unlikely that the influence of any single variable can be isolated and quantified in absolute terms. In a situation such as this where the statistically 'independent' variables are closely related, the use of a multi-variate statistic, such as a partial correlation, could be of value in estimating the ties between each of the 'independent' variables and the 'dependents' (Fig.2.2.). Unfortunately not all the data could be recorded on an interval scale of measurement and so the use of parametric statistics cannot be considered. A non-parametric statistical test for partial correlation does exist, but this requires at least an ordinal level of measurement. The use of this test is also not possible as variables such as caste and village identity are nominally scaled and so cannot be used satisfactorily in non-parametric multi-variate analysis. Despite these limitations, the presence of apparently strong links between the 'independent' variables has been established, (Fig.2.4., Appendix 4. pp. 480-490), a factor which will be of great importance when possible causal

relationships between the 'dependent' and 'independent' variables are considered in later chapters.

The methodology and scope of the Wheat Study have been discussed in this chapter, but before progressing to examine the hypotheses which have been put forward here, some background information on Bulandshahr district is necessary to put the Wheat Study in its perspective. This will form the basis of Chapter 3.

CHAPTER 3.

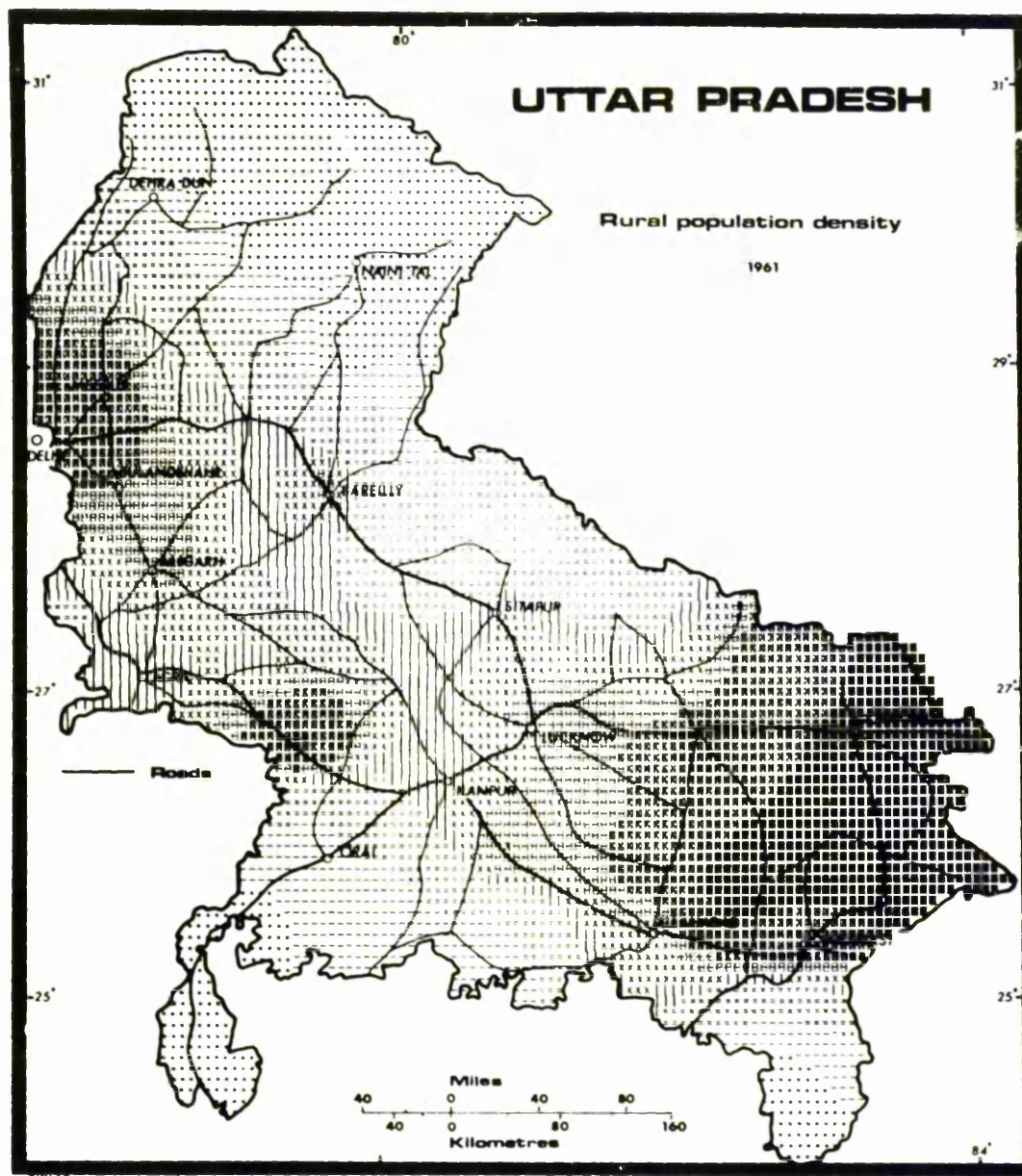
Recent agricultural developments in Bulandshahr District.

3.1. Introduction.

Bulandshahr district is situated in the doab of the river Ganga and the river Jamuna in western Uttar Pradesh (1). The river Jamuna forms the western boundary of the district, and separates it from Gurgaon in Haryana, while in the east, the Ganga divides Bulandshahr from the districts of Moradabad and Burdaun. Meerut district lies to the north, and Aligarh to the south of Bulandshahr (2) (Fig.1.1).

The district of Bulandshahr is approximately 88 km. wide and 56 km. along its north-south axis (3). The present area of the district is 4984 sq.km. (4) and it has not varied a great deal since 1865 when the final statements were made relating to the 'settlement' of the district (5). According to the District Census Handbook of 1961 only 0.13 per cent of the population in the district is classified as urban. The remainder of the two million rural dwellers (6) farm the 4558 sq.km. (91.50 per cent) of Bulandshahr devoted to agriculture, and live in the 1539 inhabited villages of the district (7).

Bulandshahr resembles the neighbouring doab districts which are often referred to as 'the alluvial plains of the Ganges' (8). The administrative boundaries do not define an area with unique properties and although it might be more logical to study the entire Ganga-Jamuna doab because of its physical uniformity (9), for purposes of practicality it is necessary to limit the size of the study area. The western districts, however, differ from



Rural population density, persons per square kilometre.

Data value extremes are 15.9 444.4

Absolute value range applying to each level

| | | | | | | | | |
|---------|------|-------|-------|-------|-------|-------|-------|-------|
| Minimum | 0.0 | 87.1 | 137.8 | 245.9 | 267.2 | 292.5 | 317.1 | 386.7 |
| Maximum | 87.1 | 137.8 | 245.9 | 267.2 | 292.5 | 317.1 | 386.7 | 444.4 |

Percentage of total absolute value range applying to each level

| | | | | | | | |
|------|------|------|-----|-----|-----|------|------|
| 19.6 | 11.4 | 24.3 | 4.8 | 5.7 | 5.6 | 15.7 | 12.9 |
|------|------|------|-----|-----|-----|------|------|

Frequency distribution of data point values in each level



Fig. 3.1

the eastern part of the state. From the physical aspect, soils differ little in other than textural qualities, but rainfall gradually increases from west to east. Mean annual rainfall on the west is 60 cm. while on the east it is 120 cm. Greater differences are apparent with respect to socio-economic activities. The population increases towards the south east of the state and according to Spate (10) this is because the number of water points increases as one moves eastwards. Whatever the reason, the population pressure is greater in the east (Fig.3.1), and there is less land for each farmer so the average farm size is reduced.

Bulandshahr is typical of the districts in the relatively prosperous western plains of Uttar Pradesh. Having briefly introduced the study district in its context of the State, we will next examine conditions at the district level. The physical features will be considered first, as these are relevant to an agricultural study such as the one carried out in the district. Following this, trends and patterns of farming in the district will be examined so that the detailed study on wheat farming in six villages can in its turn be put in perspective in terms of Bulandshahr district.

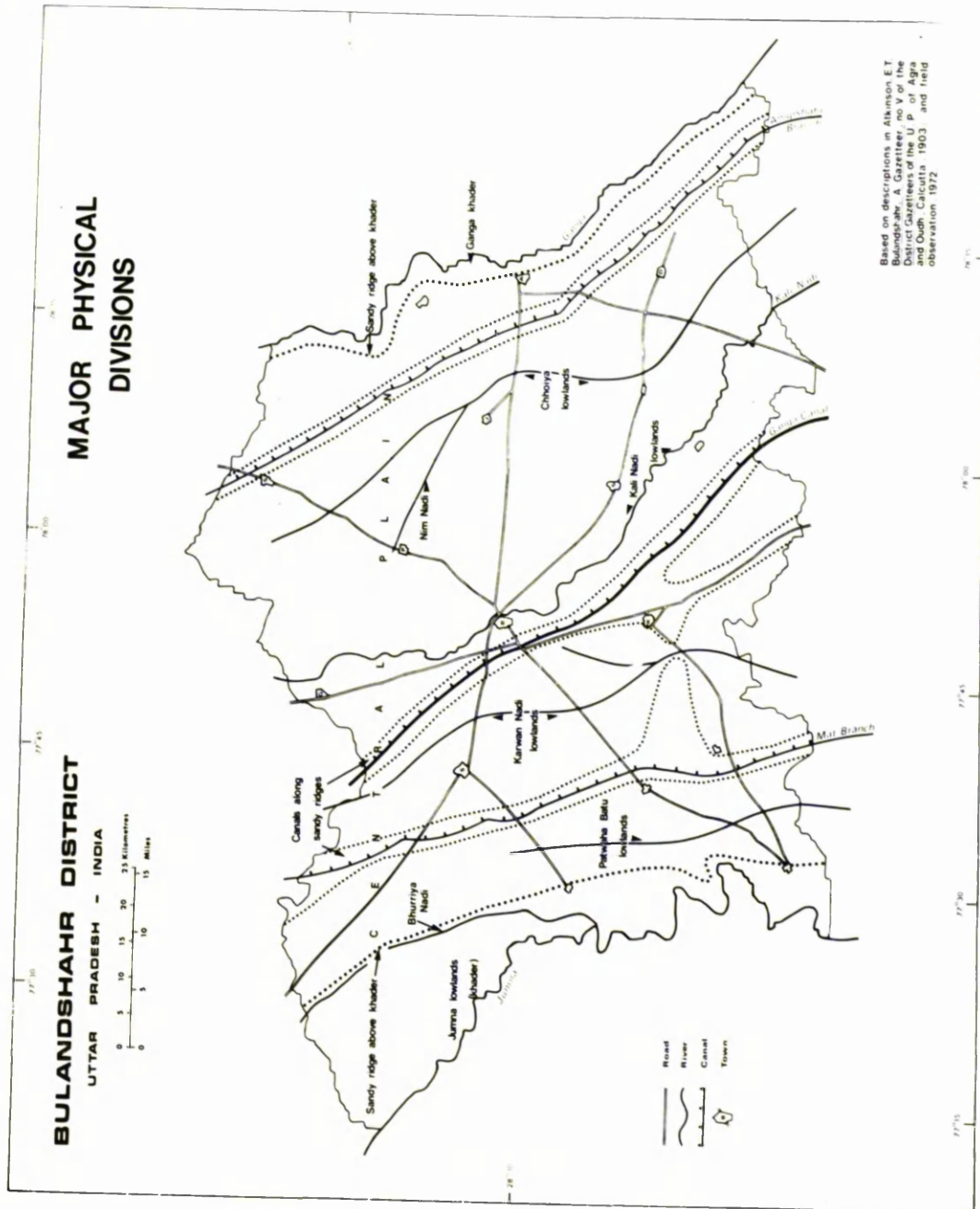


Fig. 3.2

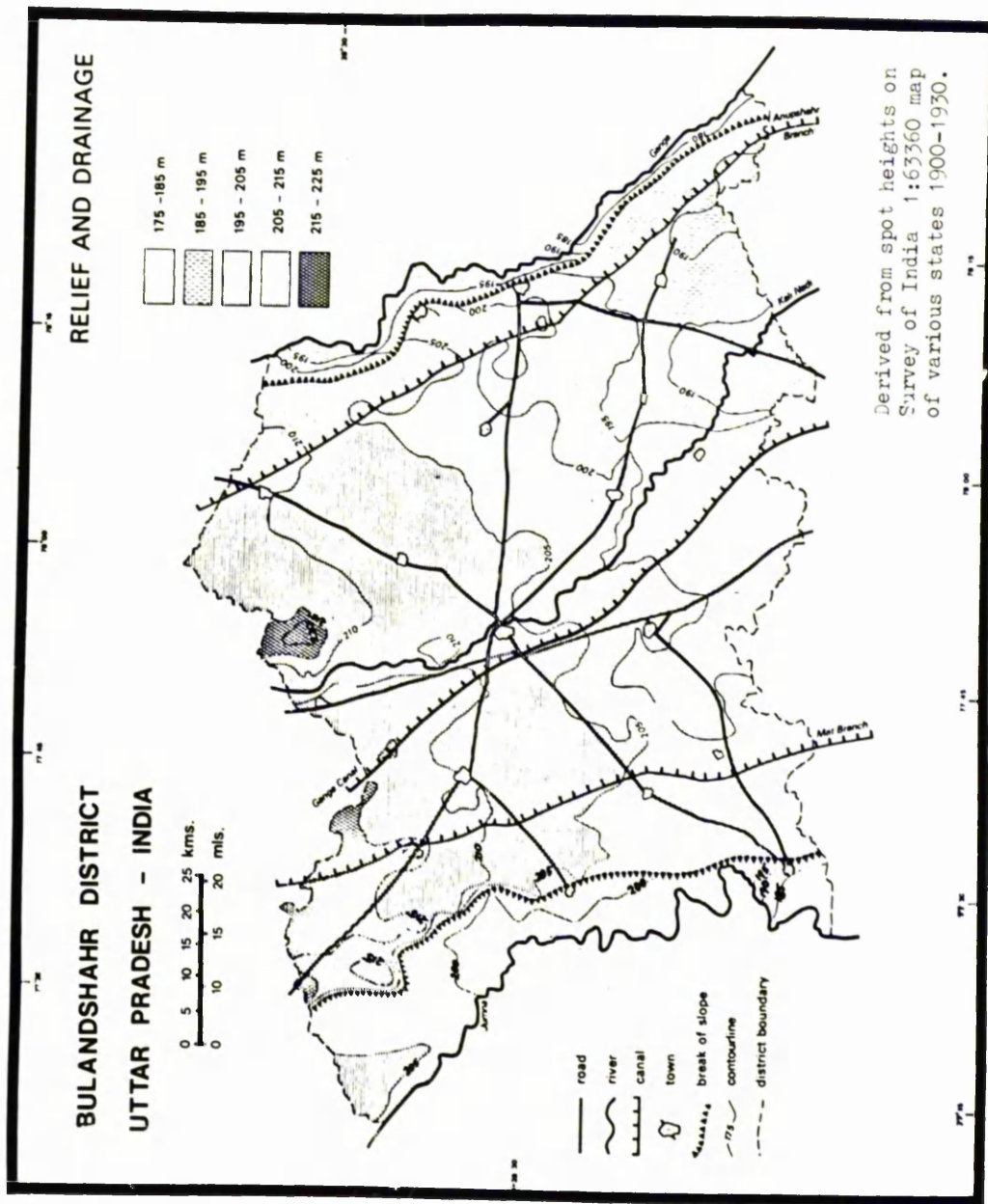


Fig. 3.3

3.2. The physical background to Bulandshahr District.

3.2.1. Landforms.

The land of Bulandshahr district dips towards the south-east, but the slope of 45 cm. in 1 km. (18 ins. in 1 mile) is almost imperceptible in the field (11). Despite the apparent lack of variation in surface conditions, the district falls into three north-west to south-east divisions (Fig.3.2 and 3.3.).

1. The Jamuna and its eastern khader¹.
2. The central plain of the district.
3. The Ganga and its western khader.

These divisions agree with Spate's generalization that

" The main physiographical variation within the great mass of the Gangetic plain is that between the upland bhangar² alluvium of the doabs and the fingers of the khader along the main streams....."(12).

No detailed survey of the landscape was carried out in Bulandshahr district during the field work period, and so it has been necessary to draw all information for this section from secondary source material, and from observation. The most comprehensive description of every aspect of Bulandshahr district is to be found in the District Gazetteer of 1903. Although not a recent publication, it contains far greater detail on the physical characteristics of Bulandshahr than the District Census Handbook of 1961 (13), or the 1971 Land Bank Survey Report on Bulandshahr (14). Nearly all the source material depends

-
1. The Khader is the flood plain of a river.
 2. Bhangar - older fluvial deposits usually situated on higher ground above flood level.

heavily on qualitative description, and it is because of this that information on the background characteristics of the district is not precise.

Maps of the district, particularly those showing features of the landscape, are scarce, and those that have been used, (Figs.3.2.and 3.3), have been compiled from field measurements carried out during the District Study of 1971-72, together with qualitative information from secondary sources and subjective observation.

1. The River Jamuna and its eastern khader.

The river Jamuna flows along the western boundary of Bulandshahr district for approximately 88 km.(15). It has frequently changed its course in the rainy season, and the width of the khader is indicative of the activity of the river. At its widest in the north of the district, the khader extends about 16 km. eastwards. Towards the south, its width narrows to six to eight km. The probable reason for this variation is that the khader area of the north consists of sands and gravels which are easily eroded, and have provided little resistance to the movement of the Jamuna. As the river flows southwards, it encounters harder belts of clay stone and kanker¹ which offer considerable resistance and seem to have been important in determining the course of the river. Much of the Jamuna within the district has been 'controlled', but after heavy

1. Kanker are concretions of saline and alkaline components which are mainly calcic in composition.

monsoons, it still tends to alter its course. The Gazetteer (1903) records that the northern part of the Jamuna seemed to have a fairly constant course as early as 1903 (16).

2. The Central Upland Tract.

The upland tract lies to the east of the Jamuna, and extends across the width of the district to the western khader of the Ganga (Fig.3.2). The rise from the Jamuna khader is rarely abrupt (17), and the transitional zone varies from approximately two and a half km. in width, in the north of the district to almost a cliff in parts of the south, where the lithology is more resistant to the effects of the river.

The upland tract can also be divided into a series of zones which trend in a north west - south east direction. Again the District Gazetteer provides the greatest detail on this area, and the changes in the area will be described briefly as they occur from west to east.

These"micro-regional differences of slope and aspect" are, according to Spate, possibly .."associated with soil or water-table variations", which are" by no means without agricultural significance" (18).

As the study has a strong agricultural bias, it is considered justifiable to devote some time to the examination of such differences, many of which are only "faintly perceptible to the eye" (19) (Fig.3.3).

i. The Sandy Ridge and the Patwaha Batu.

A sandy ridge never wider than three km. borders the western edge of the central upland tract (20). From the crest of this ridge, the land slopes gently eastwards to a line of drainage, the Patwaha Batu. Originally, this line of drainage (21) was a series of swamps in the north, which increased in volume towards the south of the district. After the construction of the Mat Branch canal, the water-table level increased and so did surface run off. The Patwaha Batu was widened and deepened particularly in the southern and central parts of the district and now forms the main drainage line between the Hindan river and the Mat Branch canal.

ii. The Central Sandy Ridge.

East of the Patwaha Batu the land rises very gradually to a ridge of sandy soil, and along this elevated strip flows the Mat Branch canal. Towards the south of the district the ridge widens and divides (22) (Fig.3.2), and one spur runs eastwards through the town of Khurja, to the Kali Nadi. Another branch of the Khurja sandy ridge runs in a south east direction, and is traced by the line of the Grand Trunk Road. The main belt of sand continues into Aligarh. Between the two arms of the sandy ridge are to be found scattered patches and hillocks of bhur¹, which are often as large as the villages that stand on them. In the north the sandy ridge is clearly defined, but as it approaches the southern boundary of the district, it becomes less distinct.

1. Bhur is sandy and uneven soil.

iii. The Central Plain.

The six study villages were located in the central plain of the district within the Kali Nadi¹ area (Figs 1.4 and 3.2) and were all within 16 km. of the district town in an area which showed little physical variation. The central plain dips towards the east from the sandy ridge passing through Khurja to the Kali Nadi (23). Three rivers drain the central plain, the Karwan Nadi, the Kali Nadi and the Chhoiya Nadi (Fig.3.2). These three rivers were all intermittent streams in the pre canal era. When the surface soil water increased after 1865, as a result of canal irrigation, the water-table rose and the channel of each of these streams was widened and deepened to cope with the greater volume of surface run off.

About half way along the course of the Kali Nadi, the river flows round a resistant bluff on which stands the district town of Bulandshahr. This town is at an elevation of 225 m. (24) and dominates the central plain. Its imposing situation and its central position make Bulandshahr the focal point of the district.

3. The River Ganga and its western khader.

The central plain falls sharply to the western bank of the Ganga, where the resistant lithology of hard clay stone and kanker form a six to eight metre high bank above the khader. These bluffs have protected the western banks of the Ganga, and so, even in the pre canal era, the river was never as erratic as the Jumna. The Ganga khader in Bulandshahr is much narrower than the khader

1. Nadi is a river.

lands in the west of the district (Fig.3.2), and never exceeds five km. In contrast to the Jumna khader, the Ganga supports temporary cultivation and not permanent settlement sites as on the khader in the north west of the district.

The bed of the Ganga has also been modified to increase its water carrying capacity. The flow of water in the river is controlled by the canal department which regulates the quantity of water in the upper Ganga canal and its tributaries, according to the volume of flow in the river. The Ganga via the Upper Ganga Canal and its Mat and Anupshahr branches, is the only river in the district from which water is extracted for irrigation on a large scale. The others are used chiefly as drains for the surface run off. One feature that all the main streams of the district now share is their permanency. With the increased surface water supply, an equally efficient drainage system is essential (25), and the adequacy of the drainage system has been questioned constantly since the implementation of the canal irrigation schemes and the salinisation of extensive areas which ensued. Much of the south west of the district in Khurja tehsil¹ is seriously affected by saline - alkali soil conditions, both naturally occurring; and aggravated by the canal irrigation schemes.

1. Tehsil: Administrative sub-division in a district.

3.3. The human background to Bulandshahr District.

3.3.1. Major land use patterns in Bulandshahr District.

The land utilisation statistics of the Uttar Pradesh department of agriculture (26) illustrate the high degree of dependence on the land (Fig.3.4). Even though the categories of land use are nowhere clearly defined, it is apparent that the net sown area occupies the greatest proportion of the district. Despite its proximity to Delhi, Bulandshahr is still very closely tied to agriculture. Of the total area, only 7.43 per cent falls under the category of 'land put to non-agricultural uses' (Fig.3.4), and according to the District Census Handbook of 1961 (27), only 13 of its settlements are classed as towns, in which live 0.13 per cent of the district's two million inhabitants.

The major forms of land use in Bulandshahr District.

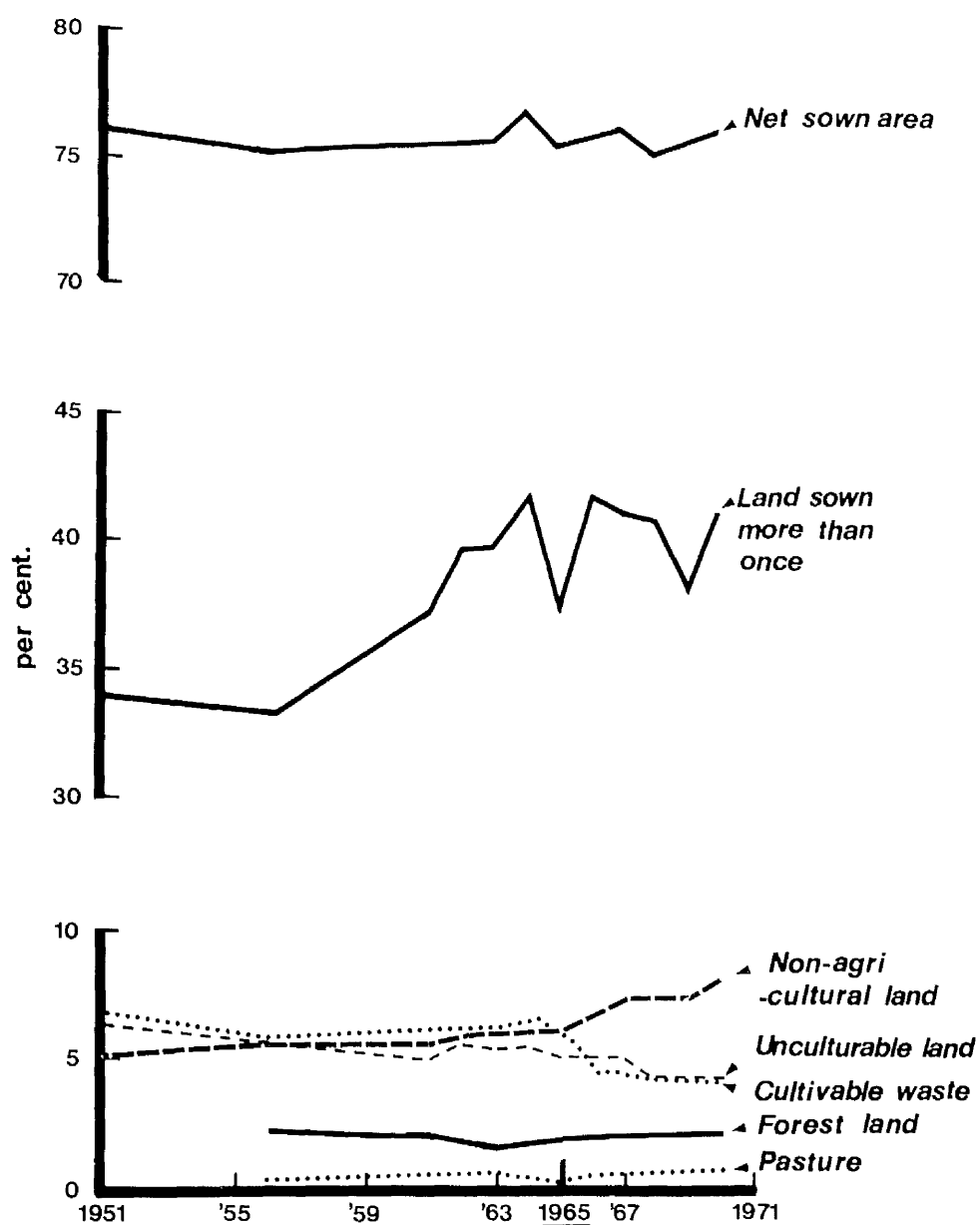
| | <u>per cent</u> |
|--|-----------------|
| Forest | 1.71 |
| Barren and uncultivable land | 4.60 |
| Land put to non-agricultural uses | 7.43 |
| Cultivable waste | 4.35 |
| Permanent pasture and other grazing land | 0.47 |
| Net sown/total area | 75.79 |
| Area sown more than once/net area sown | 45.90 |

Source: Bulletin of Agricultural Statistics for Uttar Pradesh, 1969,
(most recent complete data available).

Lead Bank Survey Report, 1970-71.

Fig.3.4.

AREA UNDER THE MAJOR TYPES OF LAND USE IN BULANDSHAHR DISTRICT.



Source: Bulletin of Agricultural Statistics
for U.P. 1951-52 - 1970-71,
Lucknow.

Fig.3.5

The patterns of the major land use categories have not changed markedly (Fig.3.5). The area of forest has declined, so has the 'barren and uncultivable waste land', though absolute changes in area are far from dramatic. 'Land put to non-agricultural uses is increasing, and although the change is slight, the growth seems to have been more rapid since 1965. The major use of the land, in its net form, however, has remained relatively constant for over half a century¹. It is however, difficult to know exactly what is included in any of these land use categories.

The dominance of agriculture in the pattern of land use is typical of most districts in Uttar Pradesh, but Bulandshahr, which lies in the central doab of the Ganga and Jamuna is in

".... an area which is comparatively better

developed than the rest of U.P." (28)

and is on "...the threshold of rapid

agricultural development...." (29),

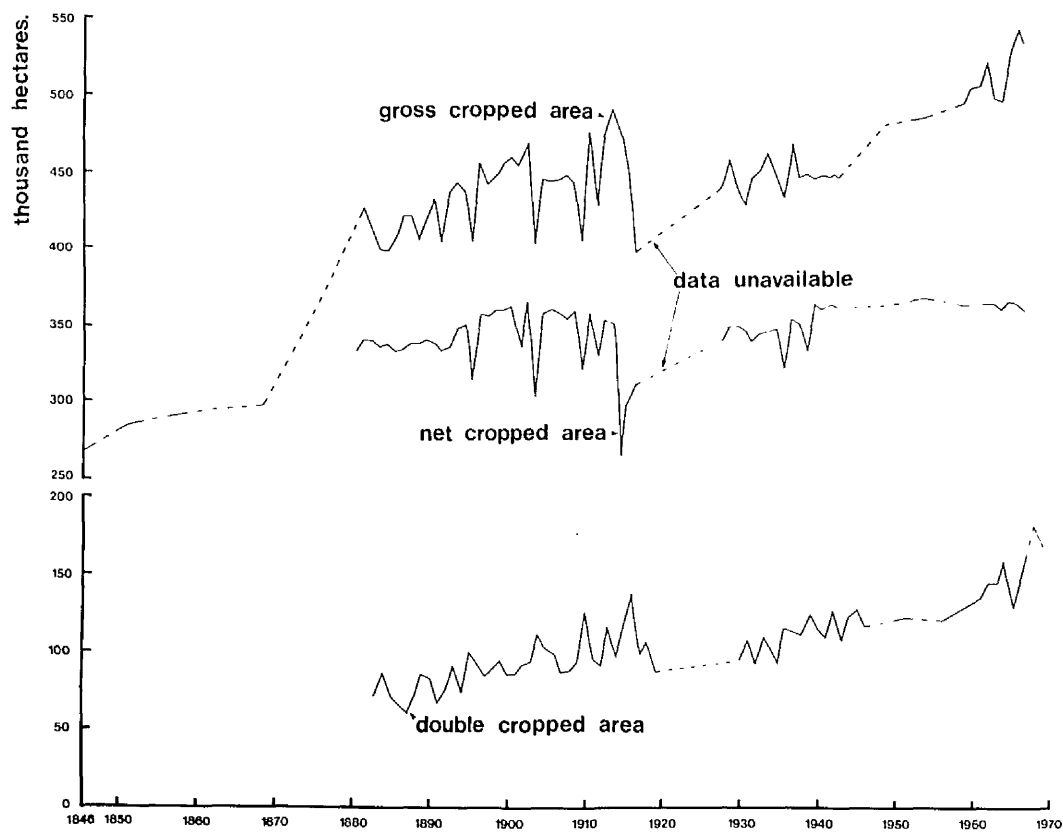
according to the Lead Bank Survey Report of 1971.

Physiographically, Bulandshahr shares the characteristics of most of the Gangetic plain, but it is one of the most agriculturally productive districts of the state, and the Survey notes the significant improvement in the agricultural conditions of the district.

1. It would have been possible to demonstrate these changes in agricultural patterns on a semi-log scale, but throughout this chapter absolute changes have been shown instead. The reasons for this have been discussed in Appendix 4.p.p.480-490.

CHANGES IN AREAL CROPPING PATTERNS.

Bulandshahr District 1846 - 1971.



Source: Indian Agricultural Statistics, 1883-1947, Delhi, & Gazetteer of Bulandshahr District, U.P., 1903, Calcutta.

Fig. 3.6

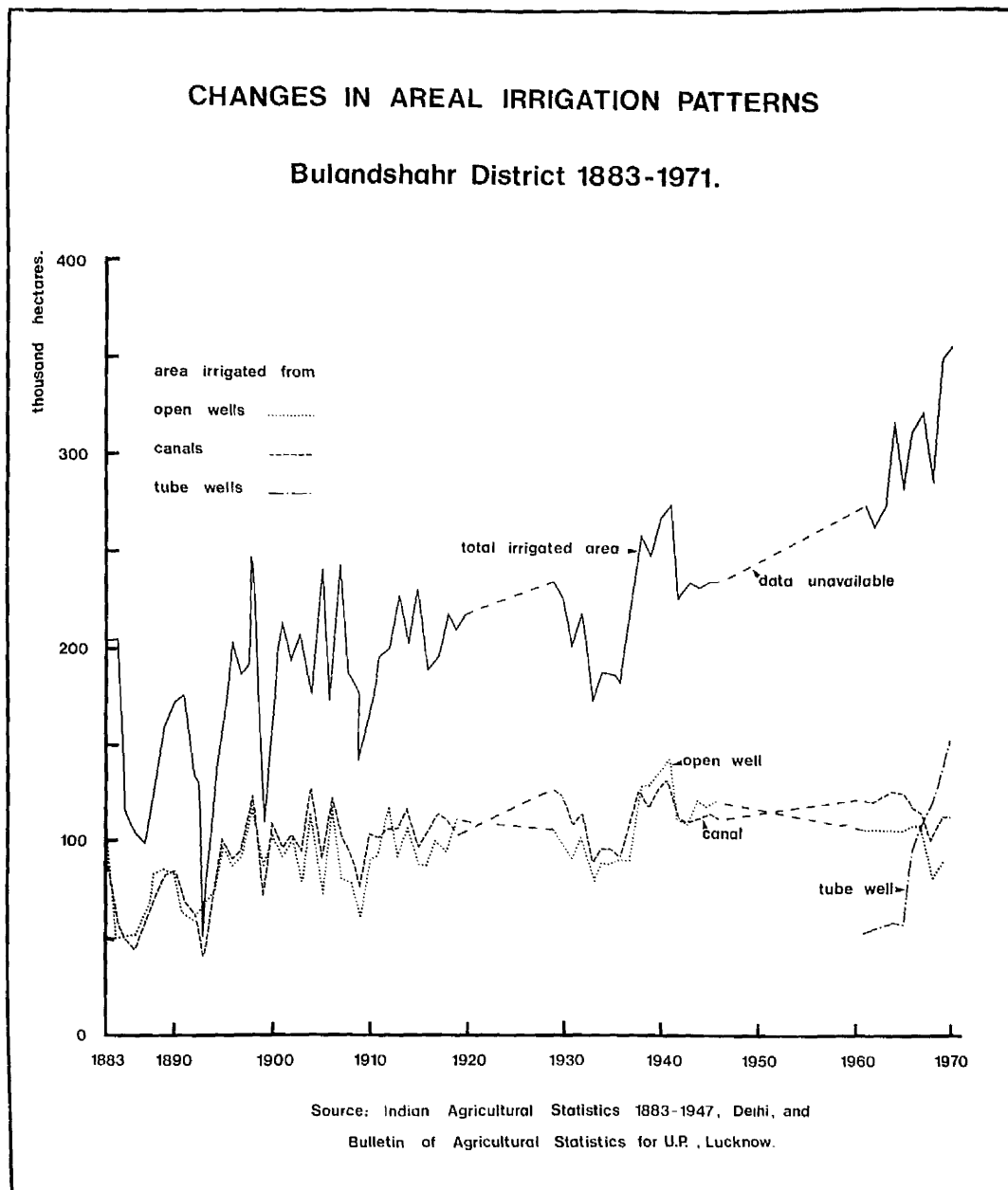


Fig. 3.7

3.3.2. The importance of canals in Bulandshahr District.

It can be argued that the recent agricultural progress that Bulandshahr district has been experiencing, as reflected in high production and yields of certain crops, results from its past. An irreversible change took place in the agricultural history of the district after 1855 when the land first received irrigation water from canals (30). A situation parallel to the present period of rapid agricultural change occurred. The net and gross cropped areas were increased, and this together with a rise in the irrigated area led to an increase in both crop yield and production. (Figs.3.6 and 3.7) (31). According to Currie, the settlement officer of 1865, the canal system had added

"....the unknown stability and certainty to cultivation, and thereby to both rent and revenue, and by making husbandry easy and profitable, it had attracted and attached to agricultural pursuits, castes and classes to whom the industry had heretofore little attraction." (32).

The water provided by the canals has given the farmers of Bulandshahr district and the other districts of the doab, the confidence to develop the agricultural potential of their land.

At this juncture it is relevant to look at the historical development of the canal irrigation system of the doab, but with special reference to Bulandshahr district. The decision to build a canal was made by the Governor General of India, after the

"....calamitous events of 1837-1838 (when) the extent of human misery caused by utter

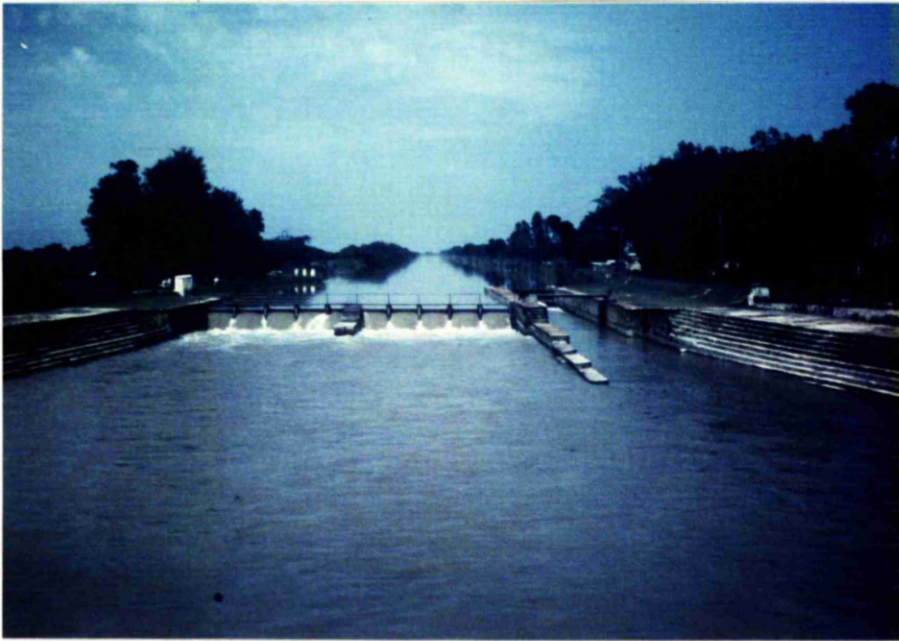


Plate 8.

Part of the Ganga canal in the Bulandshahr district, 1972.

Source: Field work for the Wheat Study - March 1972.

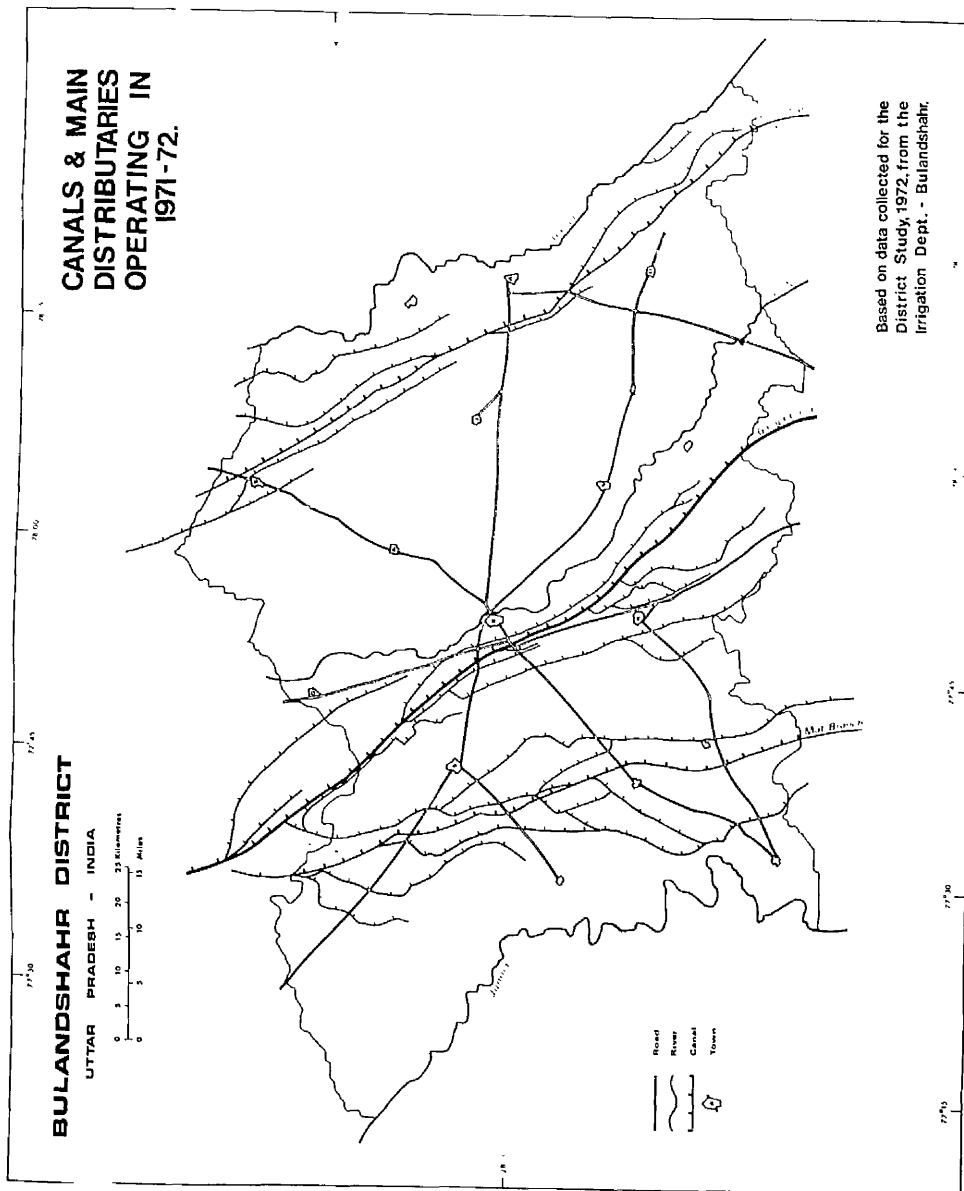


Fig.3.8

failure of crops in the Central Provinces, especially in the lower districts of the doab (led) to famine in its most aggravated form," (33).

The cost of famine relief to the British Government was high and could have been significantly lower had a canal for irrigation been in existence. To reduce the likelihood of such catastrophes occurring, the Ganga canal was constructed and completed in 1854, and its irrigation waters were first used in Bulandshahr district in 1855 (34). The canal system extends well beyond the confines of the Bulandshahr district. The main Upper Ganga canal enters Bulandshahr in the 190th. km. of its course from Haridwar (Fig.3.8). It flows along the watershed between the Karwan Nadi and the Kali Nadi, and leaves 24 km. after entering the district. Several distributaries leave the main canal on its route through the district and these can best be seen on Fig.3.8. (35).

The Anupshahr branch of the Upper Ganga canal flows along the east of the district, parallel with the main canal. This branches off the Upper Ganga canal in Muzaffarnagar. Originally this was the Fategarh branch of the main canal, but the supply of water proved insufficient and the branch practically stopped at Anupshahr. The extension of this branch was completed in 1860. (36). After the construction of the Lower Ganga canal in 1878 which leaves the river at Narora, more water was available for irrigation, and the Anupshahr branch was extended in 1879 for a further 80 km. into Etah district where it joins the Lower

Ganga canal (Fig.3.8). Although it originates in Bulandshahr, the Lower Ganga canal supplies no water to the district.

The third main irrigation channel of the district, the Mat Branch canal, flows towards the southern boundary of Bulandshahr along a ridge of coarse sandy material (Fig.3.2). This forms the watershed between the Patwaha Batu and the Karwan Nadi. The Mat Branch too is fed by the main canal which it leaves in Meerut, just before entering Bulandshahr district (37).

The Mat Branch like the main canal and the other distributaries was also excavated as a famine relief work, but became larger and more important than was initially intended. Many of the distributaries have now gone into disuse and are being replaced by tube wells. It is not known precisely which distributaries are open at present, so general areas have been shaded (Fig.3.8), to indicate whether or not the majority of the canal distributaries are in use. Field work was carried out by the District Study to determine this but even canal officials seemed unable to provide detailed records indicating which channels were still in use and which had been abandoned.

3.3.3. The main changes in agricultural patterns after 1855.

After the canals were constructed, changes in agriculture were more spectacular than they had ever been. The area under cultivation increased until it covered approximately 75 per cent of the district by the early twentieth century, compared with 54 per cent in 1854, the year before irrigation began. Unfortunately, data for Fig.3.6, which shows the gross and net cropped areas in Bulandshahr, were not available at regular intervals. The District Gazetteer of 1903 comments that the 1902 net sown area of 73 per cent

"..... must be taken as closely approaching finality, for any further extension of cultivation would be accompanied by a disproportionate loss in the necessary reserve required for fodder and pasturage." (38).

The irrigated area curve follows a similar pattern to the net sown area. The rise seems to have been steepest after 1870, but between 1871 and 1883, 553.45 hectares (136.70 acres) of land were brought into cultivation, and between 1871 and 1887, the irrigated area increased by 565 per cent.

The availability of irrigation water probably reduced the former total dependence on rainfall, and, as there were fewer crop failures through drought, the cultivator had confidence to extend the frontiers of his cultivated area. Farmers depended more and more heavily on canals, and according to the final settlement report of 1865, (39), and the Gazetteer of 1903 (40), wells were falling into disuse. The increase in water-table level, possibly due to greater run off and a series of consecutive 'wet' years, was also noted as a cause of katcha well destruction.

The very great number of wells which were abandoned may not all have been from choice.

The availability of canal irrigation water seemed to be directly responsible for the revolutionary changes in agriculture which followed 1855. Higher production, probably the net results of this innovation is comparable with the results of the present 'green revolution'. The means by which an increase in output has been achieved on either occasion, differs considerably. The former results from a change in the availability of a single variable, water. The present change in agriculture, it might be argued, was also stimulated by a single variable, the new high yielding varieties. However, before these are able to produce revolutionary yields, they require high minimum quantities of fertilizer and water. Although not absolutely essential for high yields, the availability of insecticides and pesticides is also desirable. This 'green revolution' has resulted from multi-variate change, and in consequence, the farmers are having to learn an entirely new set of husbandry practices if they are to realise the potential of the new seeds.

A second difference is that change took place in a horizontal direction in the immediate post canal era. With more water, more land was put under cultivation. The present land shortage makes it essential to increase production in a vertical direction by raising the inputs of selected seed, water, fertilizer and pesticides, and increasing the number of crops taken from the land each year. The demands made on the farmer by the new seeds are high. Not only does he have to learn the new requirements

of the plants, but also understand how they will fit into a new rotation system.

Area cultivated in each season as a proportion of the
total cropped area.

| | <u>per cent.</u> |
|--------|------------------|
| Kharif | 47.46 |
| Rabi | 52.10 |
| Zaid | 0.44 |

Source: Bulletin of Agricultural Statistics for U.P., 1969.

(The most recent, complete data available).

Fig.3.9.

Proportion of the total cropped area
sown in the kharif, the rabi and the zaid.

| | <u>Kharif</u> | <u>Rabi</u> | <u>Zaid</u> | <u>percentage of total cropped area.</u> |
|------|---------------|-------------|-------------|--|
| 1947 | 47.55 | 51.92 | 0.52 | |
| 1950 | 49.18 | 50.45 | 0.36 | |
| 1955 | 48.40 | 51.25 | 0.41 | |
| 1960 | 47.57 | 51.98 | 0.45 | |
| 1965 | 48.93 | 50.56 | 0.51 | |
| 1966 | 48.14 | 51.37 | 0.49 | |
| 1967 | 49.60 | 49.91 | 0.49 | |
| 1968 | 49.57 | 52.32 | 0.54 | |
| 1969 | 47.48 | 51.98 | 0.53 | |
| 1970 | 46.37 | 59.75 | 0.46 | |
| 1971 | 47.46 | 52.10 | 0.44 | |

Source: Bulletin of Agricultural Statistics for U.P.

1947-1971, Lucknow.

Fig.3.10.

3.3.4. Recent changes in agricultural patterns in Bulandshahr District. (Mainly post 1947).

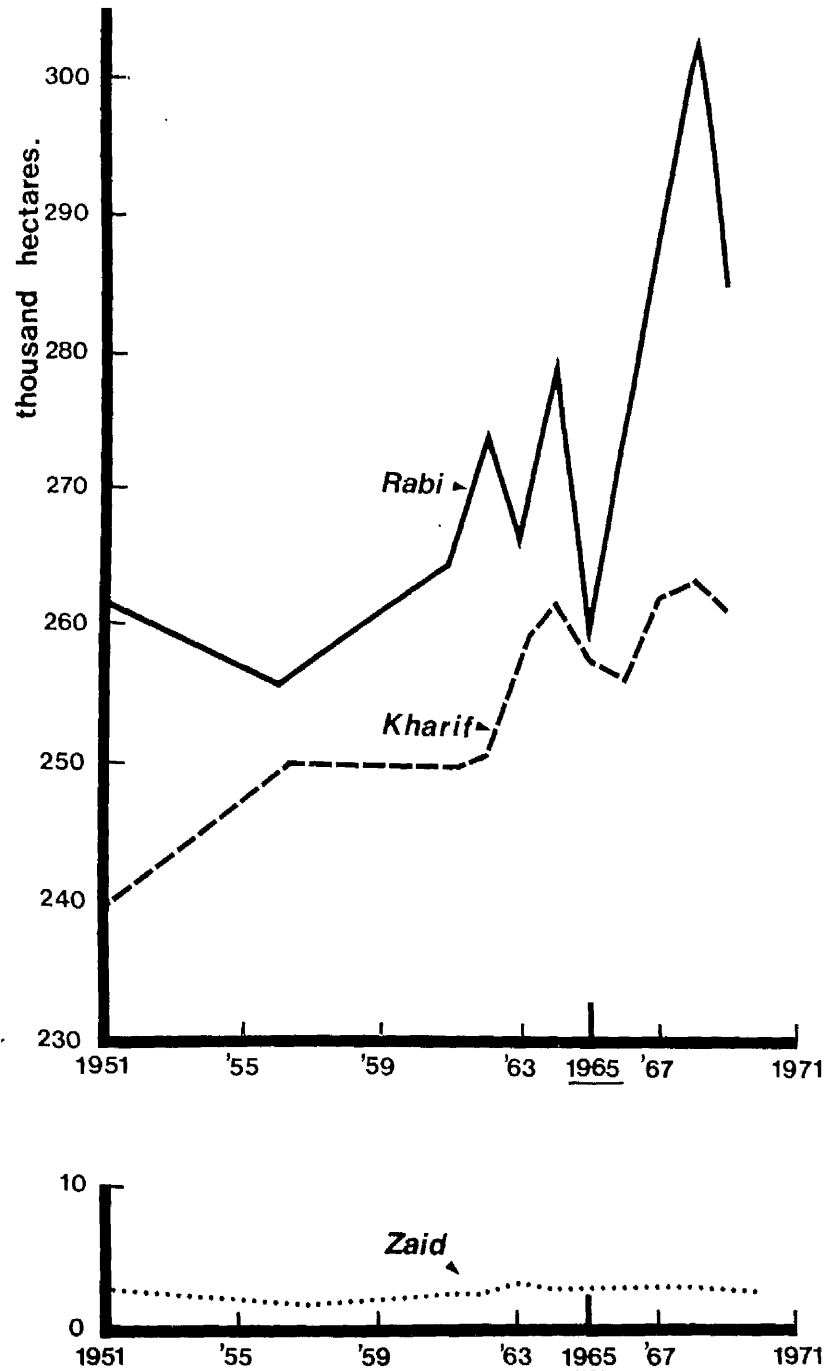
As Bulandshahr is a member of the High Yielding Varieties Programme, one would expect that the high yielding varieties are becoming established in the district. Several aspects of agriculture have been selected to see if any change in the approach to farming has become apparent since 1965 when the new seeds were introduced to the district. As much information as possible has been collected since 1947 so that the 'pre' and 'post' green revolution periods may be compared.

1. Changes in cropping patterns.

Despite the introduction of the 'new technology' the cropping patterns of the district are still typical of Uttar Pradesh and much of northern India. There are three seasons in the agricultural year; the kharif, (July - October), the rabi, (October - April), and the zaid, a short season lasting from late March or early April to June or July.(41). Not every farmer takes three crops from his land each year, and again, the statistics recorded by the Uttar Pradesh department of agriculture illustrate that in Bulandshahr district, the area sown during the rabi is greatest. The cropped area during the kharif is slightly less, but it is evident from Fig,3.9 that a very small area is cropped during the summer season.

Wheat, barley, gram, linseed, rape, mustard and pulses are the main rabi crops, while maize, rice and the millets, jowar and bajra, are grown in the kharif. Catch crops of melons, tobacco, chillies, onions or pulses can be harvested in the zaid, but are relatively unimportant in Bulandshahr. Sugar cane is

THE AREA SOWN IN THE
KHARIF, RABI AND ZAID SEASONS.



Source: Bulletin of Agricultural Statistics
for U.P. 1951-52 - 1970-71,
Lucknow.

Fig. 3.11

another important cash crop of the district, but its annual life cycle does not fit easily into the kharif-rabi-zaid cropping system. For the past 25 years the proportions of land sown each season have remained the same (Fig.3.10), but in absolute terms, the areas under each of the kharif and rabi seasons have increased by some 20-30,000 hectares. This rise however, has not been paralleled in the zaid (Fig.3.11). The shorter maturation period of the new varieties, due largely to their insensitivity to day length (42), could enable the farmer to harvest an extra crop either at the beginning or at the end of the rabi. Many of the recent agricultural policies are attempting to increase the productivity of the land by multiple cropping (43), and although the proportion of the area which is sown more than once has risen over the past 20 years in absolute terms (Fig.3.5), the area cropped during the zaid can contribute little to the increase in the gross cropped area.

2. Changes in the relative importance of crops grown in the Bulandshahr District.

Little mention has been made so far about the crops that are grown in Bulandshahr district. Food crops have always been of great importance and the pressures exerted by an ever growing population have forced those responsible for administering agriculture to give most attention to food crops. Fig.3.6 shows the absolute changes in the areal cropping pattern of Bulandshahr since 1846, and so links the period discussed in section 3.3.2 & 3.3.3 with the present.

The proportion of the cultivated area under wheat has always been high, but farmers are concentrating on wheat along with other

food crops and are starting to grow more wheat now that it is worth their while to do so. In 1965, the United States changed its aid policies from long to short term agreements (44).

America began to allocate food in terms of months, not years, and this potential shortage did a great deal to boost the prices of home wheat which had been severely depressed by the heavy grain imports.

With returns rising, it became more profitable for the farmer to grow food crops, particularly if the high yielding varieties were planted. India launched a High Yielding Varieties Programme in early 1966 (45), and through this scheme it became more profitable for the farmer to concentrate on food crops, and particularly those species for which hybrid seed had been developed. Since the introduction of genetically improved varieties, the relative importance of individual food crops continues to change. Information about the precise dates of adoption of the high yielding varieties is scarce ¹. The District Study, in 1971-72 showed that the majority of the farmers began growing high yielding varieties of wheat in 1968. Unfortunately no similar data were collected for the other new and improved varieties of seed, but the District Study 1971-72 does agree with the results of a study carried out by Lockwood, Mukherjee and Shand in Muzaffarnagar, 112 km. to the north of Bulandshahr (46).

1. Certain farmers who can afford to pay, obtain their newest varieties from black market supplies before the seed is officially released. Consequently, these cultivators are guarded about giving their dates of adoption of the high yielding varieties in order to protect themselves and their suppliers.

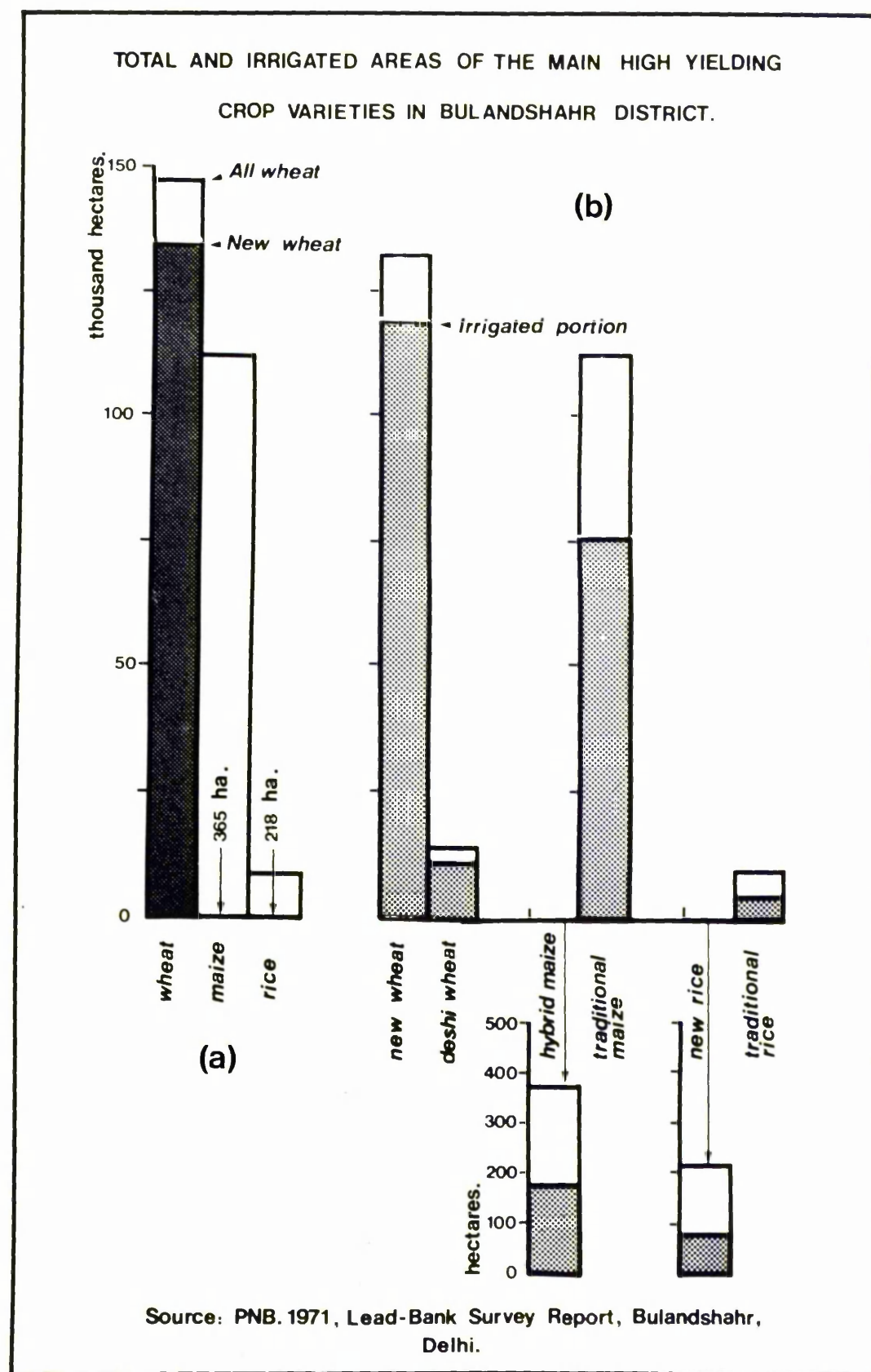
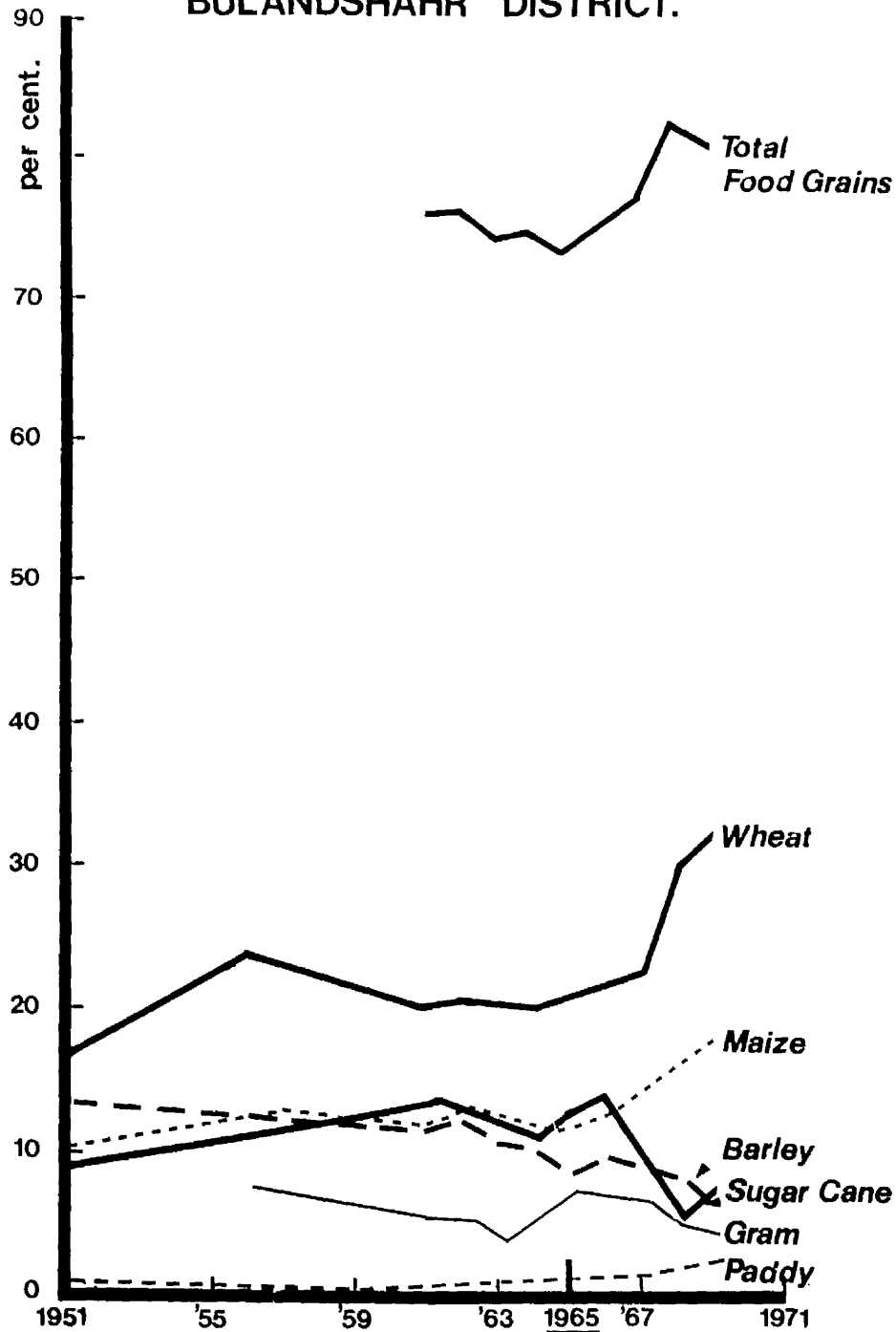


Fig. 3.12

PROPORTION OF THE TOTAL CROPPED
AREA UNDER PRINCIPAL CROPS IN
BULANDSHAHR DISTRICT.



Source: Bulletin of Agricultural Statistics
for U.P. 1946-47 - 1970-71,
Lucknow.

Fig. 3.13

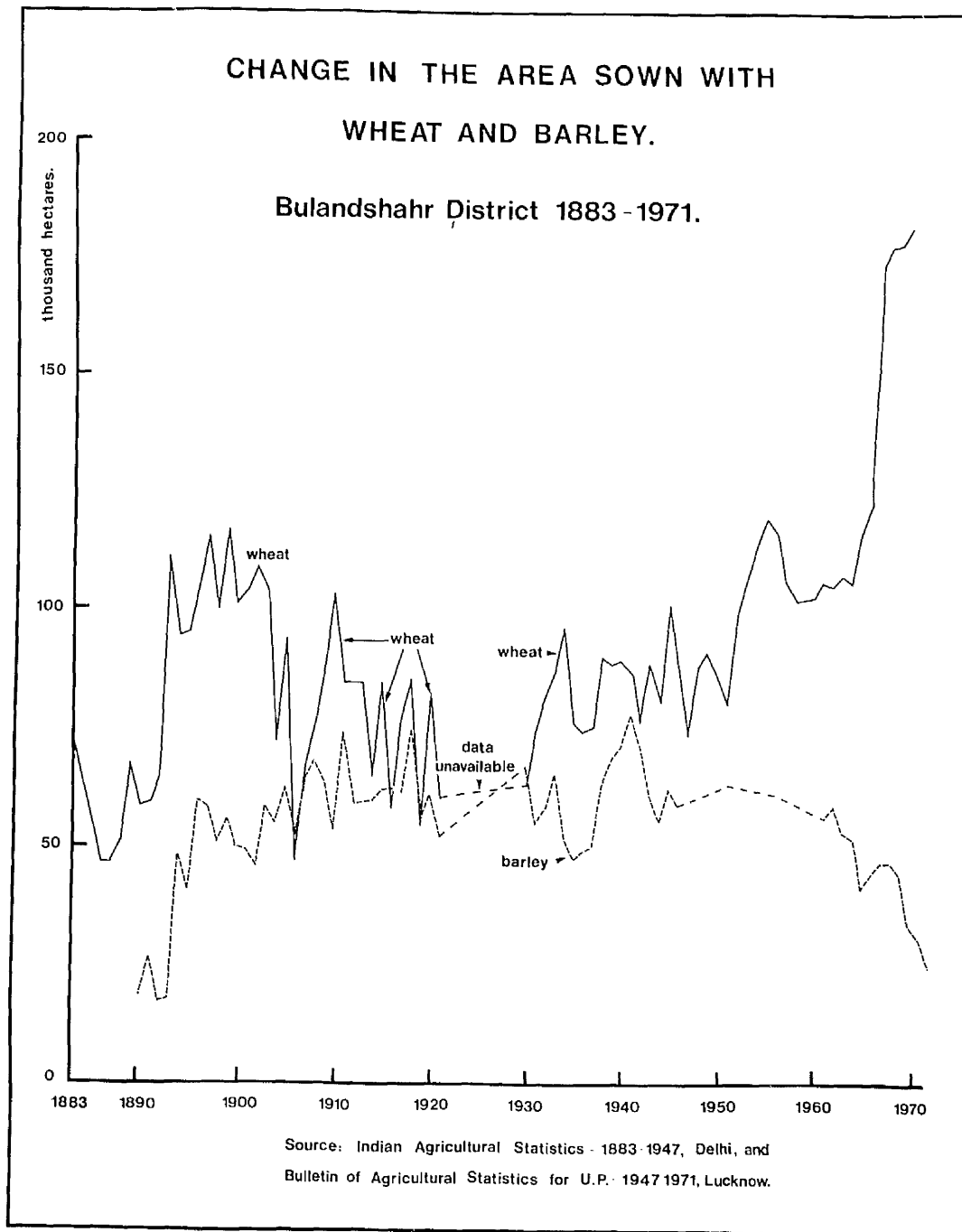


Fig.3.14

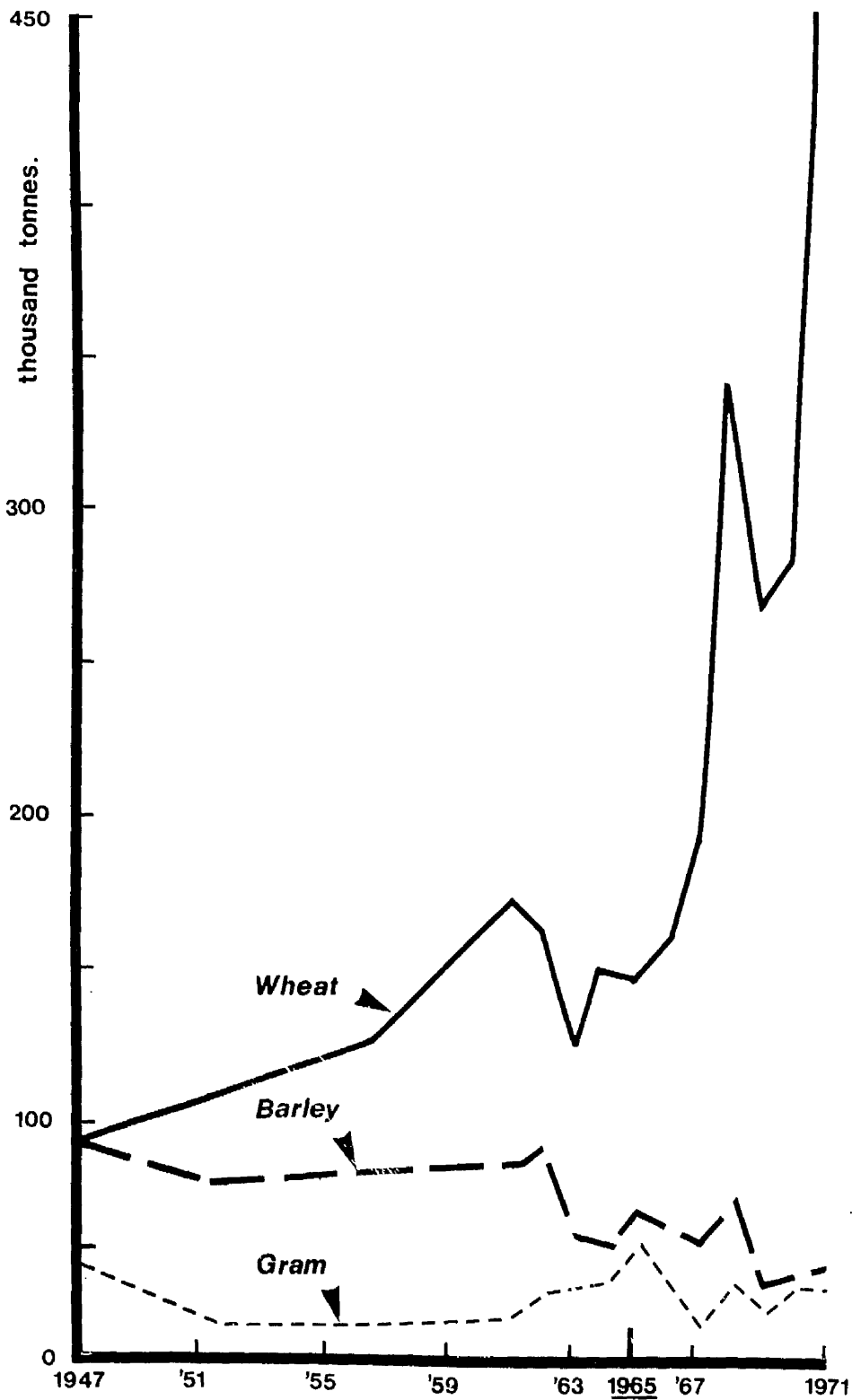
Data of present areas under the new high yielding varieties in Bulandshahr district are available in the Lead Bank Survey Report. Fig.3.12 shows the areas sown with the genetically improved species of wheat, maize and rice (Fig.3.12) with relation to the total area sown to these crops (Fig.3.12a). It is apparent that the high yielding varieties of wheat are very popular in the district, while the areas under hybrid maize and rice are insignificant. It must be mentioned that the source of these statistics is not clear, but as they are the only data of their kind available, they have been used with due reservation. Other data of a less detailed nature relating to changes in the importance of selected crops grown in Bulandshahr district have been obtained from the U.P. Department of Agriculture, statistical publications. These data do not, however, give details of areas under particular varieties, and for this reason extensive field work was necessary to determine such information.

The Rabi crops.

Wheat.

Fig.3.13 shows quite clearly that wheat is the most important crop of the district, and its importance in both absolute and relative terms seems to be increasing. Wheat has always been the main rabi crop in Bulandshahr and Fig.3.14 shows its dominance over barley since 1883. As wheat farming has gained momentum since the mid 1960s, the areal curves are 'moving' apart and, in similar fashion, the production figures of wheat rose after 1966 when the advantages of the new high yielding varieties first became apparent. Brown (1970), dates the 'yield take-off' in wheat at 1967, in India (47). If the increase in production

PRODUCTION OF THE MAIN RABI CROPS IN BULANDSHAHR DISTRICT.



Source: Bulletin of Agricultural Statistics
for U.P. 1946-47 - 1970-71,
Lucknow.

Fig.3.15

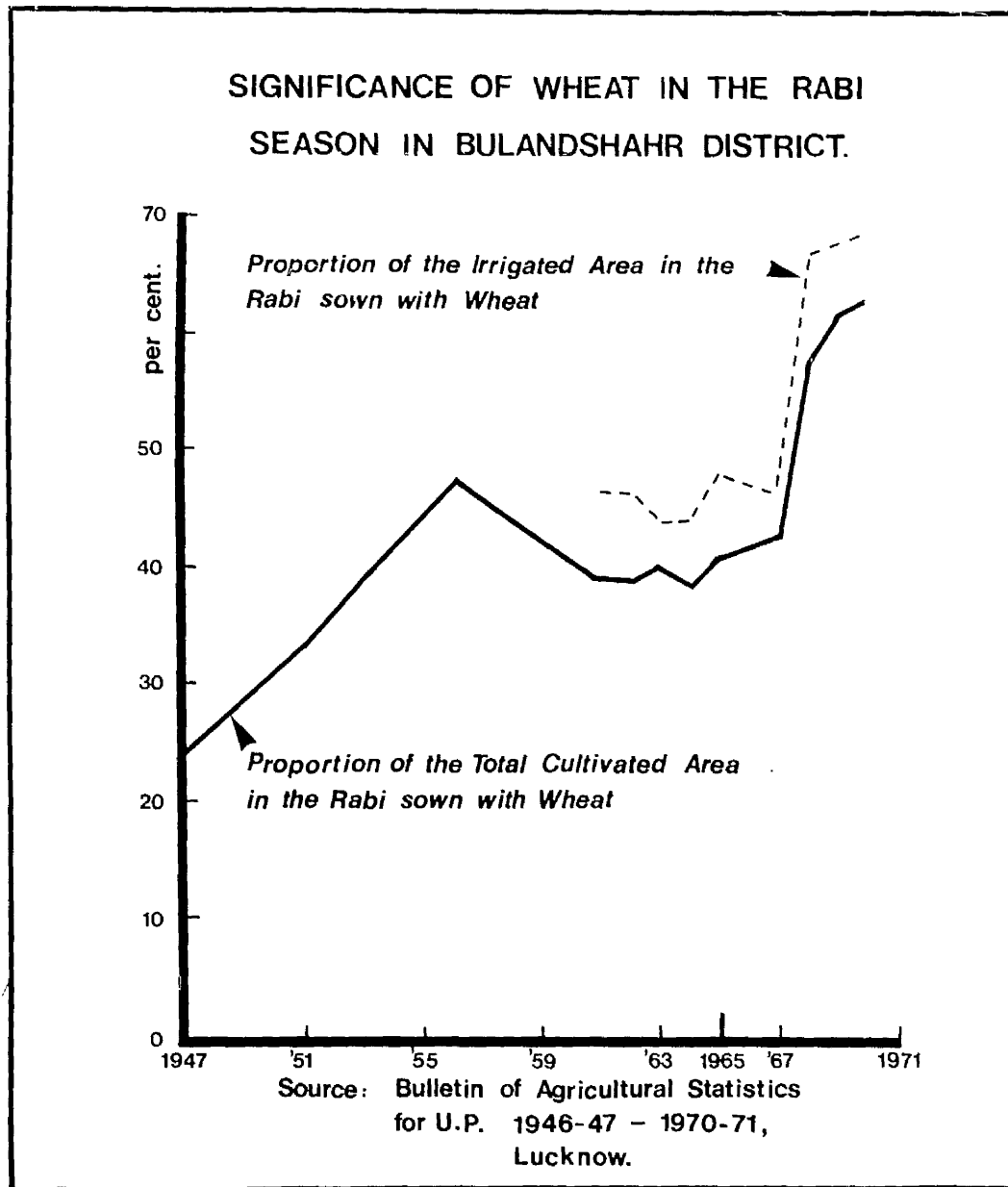
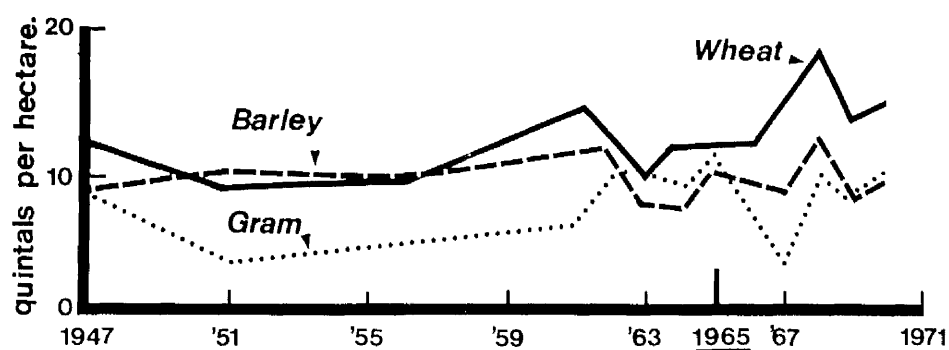


Fig. 3.16

ESTIMATED YIELDS OF THE MAIN RABI
CROPS IN BULANDSHAHR DISTRICT.



Source: Bulletin of Agricultural Statistics
for U.P. 1946-47 - 1970-71,
Lucknow.

Fig.3:17

shown on Fig.3.15 was due to the high yielding varieties of wheat, it may indicate that innovation had been earlier in Bulandshahr than the average for the wheat growing areas of India. The rise between 1967 and 1968 however, is almost six times as great as in the previous year, and if the high yielding varieties were once again the cause, this particular period would coincide with Brown's suggested take-off for India. The one downward fluctuation in the production curve in 1969 might have been influenced by the low rainfall in the monsoon of 1968. It seems likely that surface sources of irrigation may have been short of water. The irrigated area of wheat has risen to match the production curve, and despite the reduced rainfall of 1968, the irrigated area had increased by the following rabi (Fig.3.16). The availability of tube well water which is not directly dependent on local climatic conditions might explain this (Fig.3.23).

Despite an increase in the irrigated area, the production and yield of wheat fell after 1968 (Fig.3.17), possibly because the irrigation sources were unable to provide an adequate quantity of water for the area covered. After 1968 the curve has continued to rise. The yield figures for wheat do not rise in a similar fashion to those for production. A peak was reached at 18.25 quintals per hectare in 1968, after which yields have been considerably lower (Fig.3.17). A fall in the quantity of fertilizer used over the district may explain part of the downward trend though the value of correlations of fertilizer and yield statistics averaged for the district and based on different sample conditions are extremely limited.

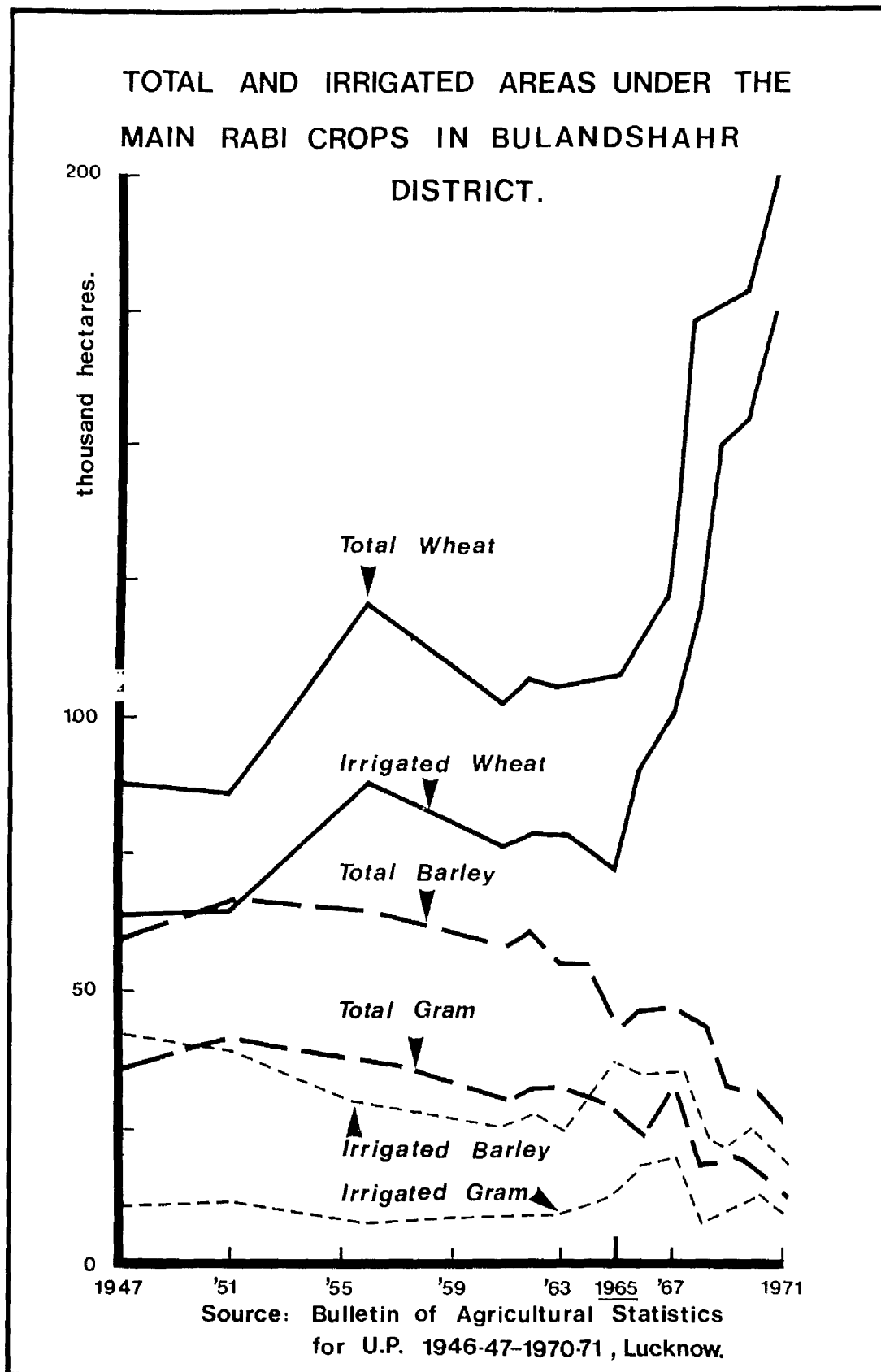


Fig. 3.18

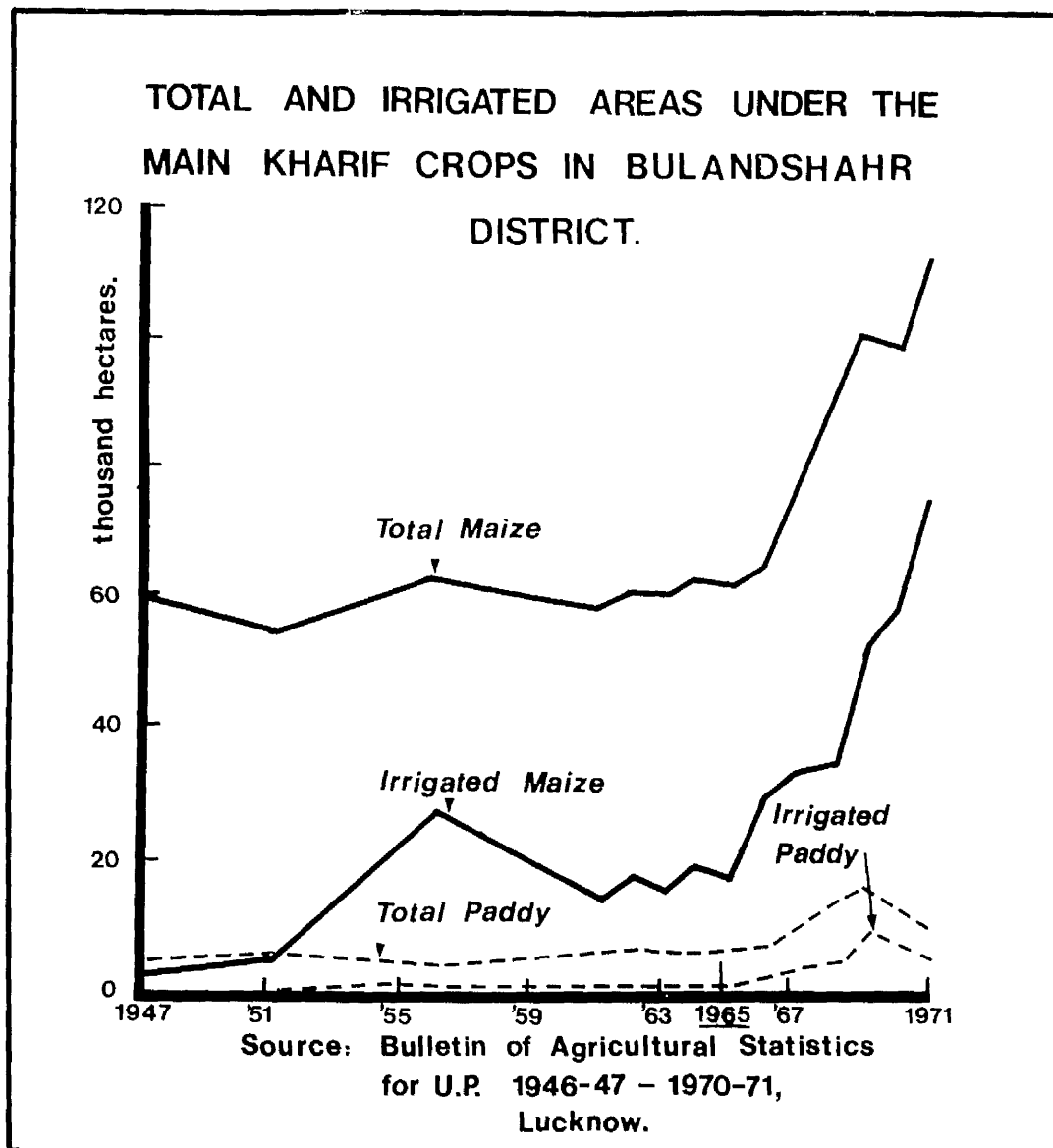
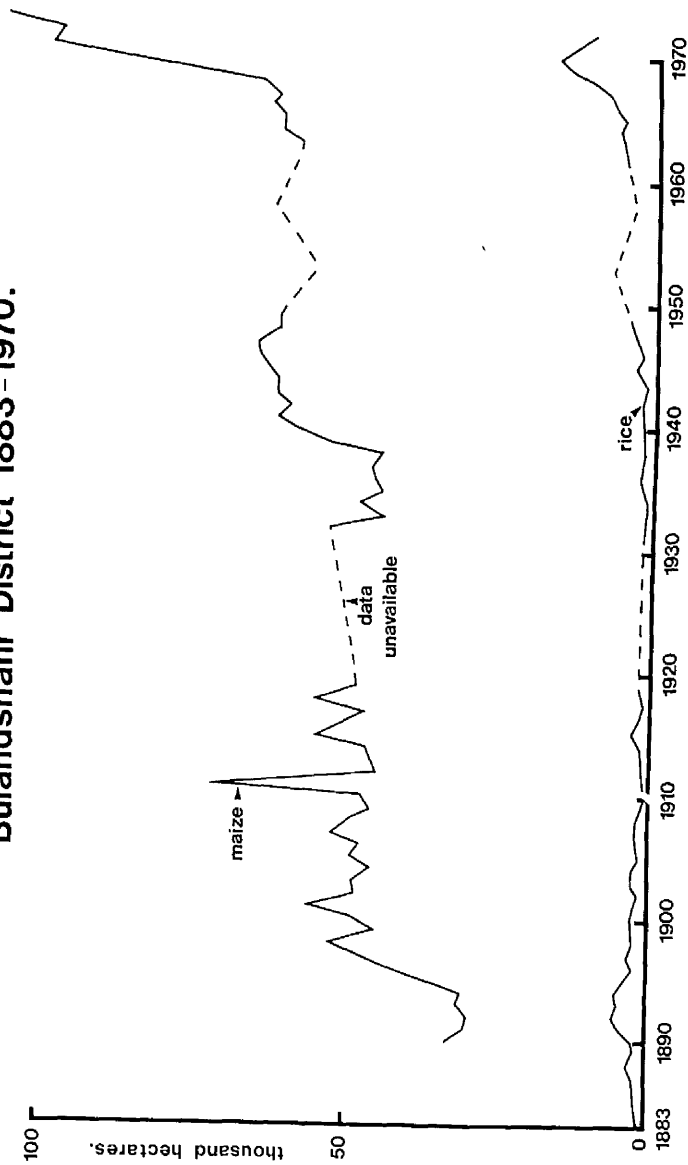


Fig. 3.19

CHANGE IN THE AREA SOWN WITH

RICE AND MAIZE.

Bulandshahr District 1883-1970.



Source: Indian Agricultural Statistics - 1883 - 1947, &
Bulletin of Agricultural Statistics for U.P. - 1947-1970.

Fig.3.20

The increase in wheat production does not seem to result from the great increase in yields which supposedly characterise the new high yielding varieties of wheat. Yields have not markedly increased since 1966, but the rapidly rising production curve must be the result of an increase in the total area under wheat and a rise in the proportion of the crop which is irrigated. (Fig.3.18). This increase in the irrigated area at least ensures that total failure of the crop does not occur. In 1971-72 the proportion of the wheat crop which was irrigated reached its highest level, and appeared to be expanding at the expense of the other main rabi crops of barley and gram (Fig.3.18). Before 1965, the areas sown to barley and gram were much closer to wheat than they are at present. After the middle 1960s, the areas sown to these now less financially rewarding crops fell, and continued to fall (Fig.3.18). Although the fall is not as great as the absolute rise in the area under wheat, Fig.3.18 shows that wheat is expanding to cover land previously sown with barley and gram. Informal discussions with the farmers during the field work confirmed these results.

The Kharif crops.

The main kharif crops are maize, rice and millets, jowar and bajra. Data have not been obtained for jowar and bajra, but temporal changes in the patterns of maize and rice will be discussed.

Maize.

The changes shown by maize as a kharif crop strongly resemble the patterns of wheat in the rabi, though in absolute terms maize covers a lesser area in the kharif than does wheat in the rabi (Figs.3.18 and 19). The area planted with maize has remained constant since the early twentieth century (Fig.3.20) but has

risen markedly since 1965 with one very slight recession between 1969 and 1970, but this trend was sharply reversed between 1970 and 1971 (Fig.3.20).

Maize production has increased since the mid 1960s due mainly to the increase in the area under the crop. Fig.3.19 shows the relationship between the irrigation curves and the area curves which gradually appear to be merging, so indicating the increase in the area of maize which is being irrigated. About two-thirds of the entire crop received irrigation water in 1972 (Fig.3.19). Yields of maize have risen since the beginning of the 1960s, but in 1971 they were not as high as in previous years. According to district extension workers, more irrigation water, fertilizer and plant protection measures have been responsible for the raised yields.

One variable which seems quite insignificant in the district is improved maize seed. Fig.3.12b shows that out of a total of 112,716 hectares which were sown with maize in the kharif of 1970, only 365 hectares were sown to hybrid varieties. Local maize still seems to be far more popular in Bulandshahr district, probably because it has been less publicised than the new wheat. The high yielding maize seeds, unlike new wheat and new rice were not developed abroad but have been produced in India with germ plasm from Mexico and Central America (48). The field work in 1972 showed that many farmers had difficulty distinguishing local from improved indigenous varieties of wheat. Little indication is given of the methods of data collection used by the Lead Bank Survey, but there could have been a confusion of

terms 'old' and 'new' maize, as the number of adopters of the new maize seed seems absurdly low.

If genetically improved seed has not been widely used, it is thought that the changes apparent in the data relating to maize must result from new approaches to farming.

Rice.

The area sown to rice in Bulandshahr district has always been small (Fig.3.20), as the cost of irrigating rice deters most farmers from growing it. Rice increased in area after 1966, corresponding with the period when high yielding varieties of rice were brought into use in India (49). The Lead Bank Survey Report however claims that in the kharif of 1970, only 218 of the 9,670 hectares sown with paddy were under the new varieties (Fig.3.12b). From these data it does seem unlikely that the genetically modified seed has been responsible for an increase in production. Inputs of water and fertilizer for 'new' rice are costly and in relatively short supply, and most farmers find maize the more profitable kharif crop.

Sugarcane.

Finally mention must be made of sugarcane which does not fit into the wabi/kharif classification as it is generally sown in January and harvested the following November. Although sugarcane is not a typical food crop, it is worthy of mention as it is an important cash crop of Bulandshahr and second only to wheat. The district is now the main sugar producer of the doab districts in Uttar Pradesh. The production curve bears

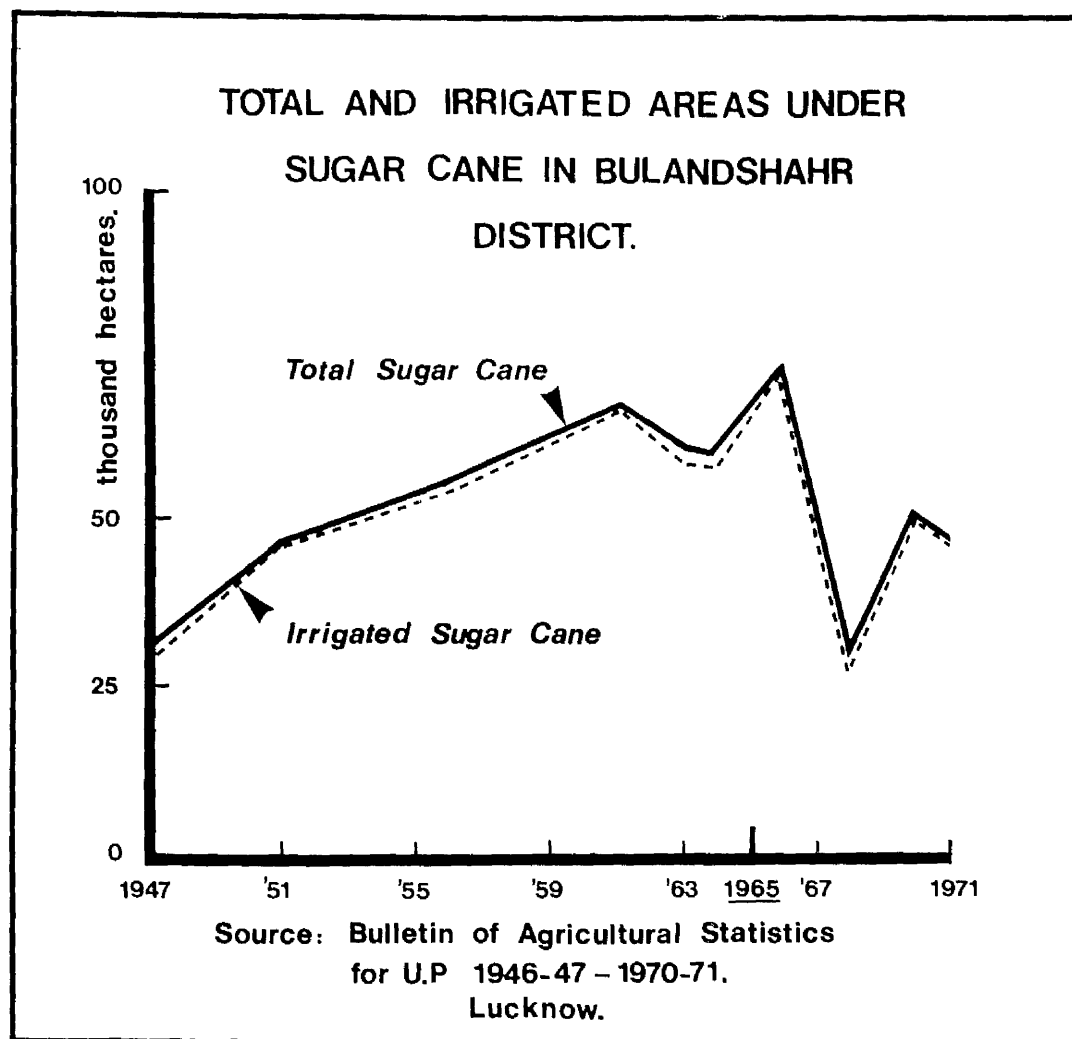
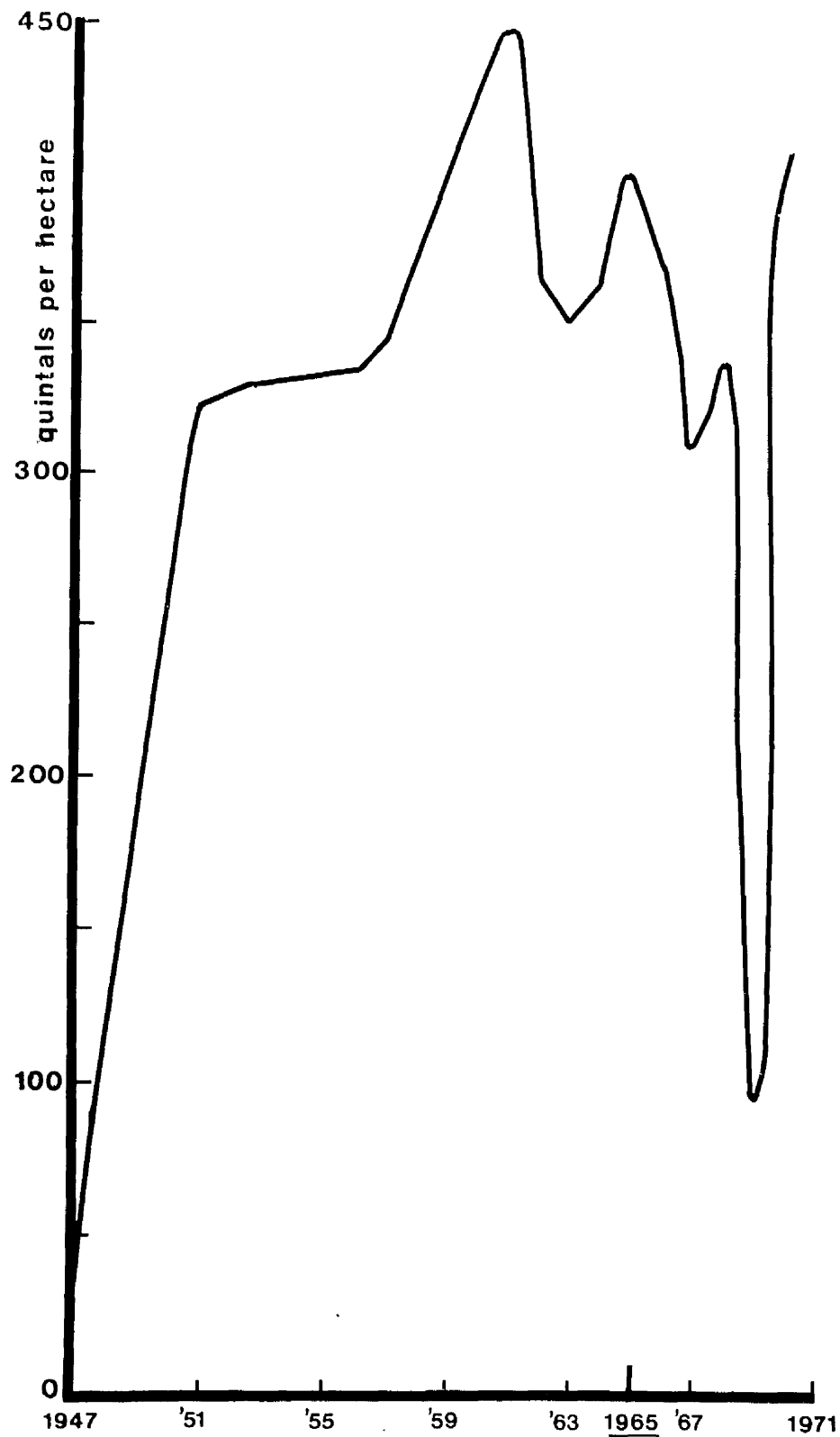


Fig. 3. 21

SUGAR CANE YIELDS IN BULANDSHAHR DISTRICT.



Source: Bulletin of Agricultural Statistics
for U.P. 1946-47 - 1970-71,
Lucknow.

Fig. 3.22

little relationship to the yield of cane. For example the low production figures of 1964 and 1968 are accompanied by high yields . According to the District Agricultural Officer, yields vary with the availability of irrigation water, and this has resulted in a very erratic yield curve (Fig.3.22).

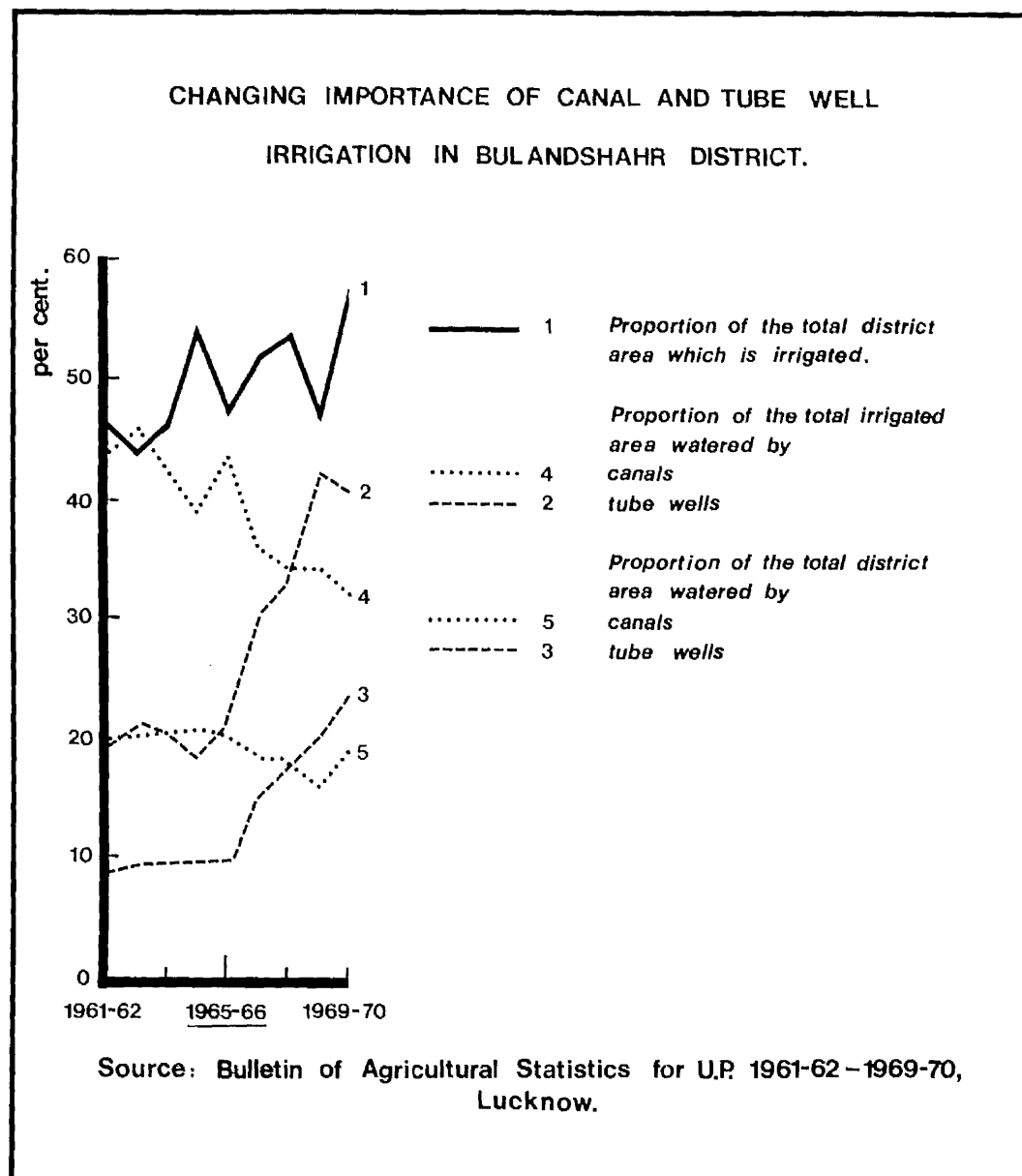


Fig. 3.23

3. Changes in irrigation patterns within the district.

Bulandshahr, Meerut, Aligarh and Muzaffarnagar have the best irrigation facilities of the 54 districts in the state (49). Over 70 per cent of the net sown area is irrigated and the area which is watered more than once is also increasing (50). The main source of water in the district is now from tube wells which overtook canals between 1967 and 1968 in terms of the area which they irrigated respectively (Fig.3.23). Until 1967, canals had been the main source of irrigation, with wells, pukka¹ and katcha, second on the list. Crops which require a considerable quantity of water could not be grown successfully at any distance from the canals, and in addition to the initiation of major schemes for irrigation, the Indian government is encouraging farmers to develop private tube wells and to use pumping sets. These minor irrigation sources are able to supply the farmers' immediate needs for water, while the major schemes will be of value to the cultivator in the long term only.

Farmers who have adequate land can obtain loans of money and equipment from co-operative banks for the construction of private tube wells (51). In rural areas which are electrified, and away from canals, tube wells have been responsible for the vast increase in the irrigated area. The jump in the area watered by tube wells between 1965 and 1966 took place at the time when the new high yielding varieties, particularly wheat, were coming into use. Although there is little information concerning the area sown with the new seed at that time, it does seem likely that this vast increase in the irrigated area

1. Pukka - Complete, of good material, permanent.

reflects a demand for larger quantities of irrigation water by farmers, and so possibly indicates the adoption of new farming techniques. The advent of the tube well has been paralleled by a decline in the relative importance of canals, and even a decrease in their use in absolute terms is evident from Fig.3.23.

One of the main aims of agricultural research is to discover techniques of farming which free the cultivator from the 'ties' of an unpredictable climate. Securing reserves of adequate irrigation water to avert the effects of possible monsoon failure, is therefore essential. The curves showing the areas irrigated by canal and open well fluctuate in the direction opposite to the curve of the total irrigated area (Fig.3.7). This is probably because in drier years more water is used for irrigation whereas when the monsoon rains are heavy, less water is extracted from these sources. This agrees with work carried out by Raheja (1967)(52). Tube wells were in their infancy during the unfavourable season of 1965, but the upward trend of the area served by tube wells during the 1968 drought is impressive.

If the major sources of irrigation became both adequate for the needs of the crops and independent of the local climate, this would give the farmers far greater scope to manipulate the agricultural ecosystem. If irrigation facilities continue to increase as they have been doing, such a situation could be within sight. At present however, the electricity requirements of the tube wells are not adequately met. On average, the months of June to September receive a constant electricity supply. From October to March the power supply is cut from two to four hours

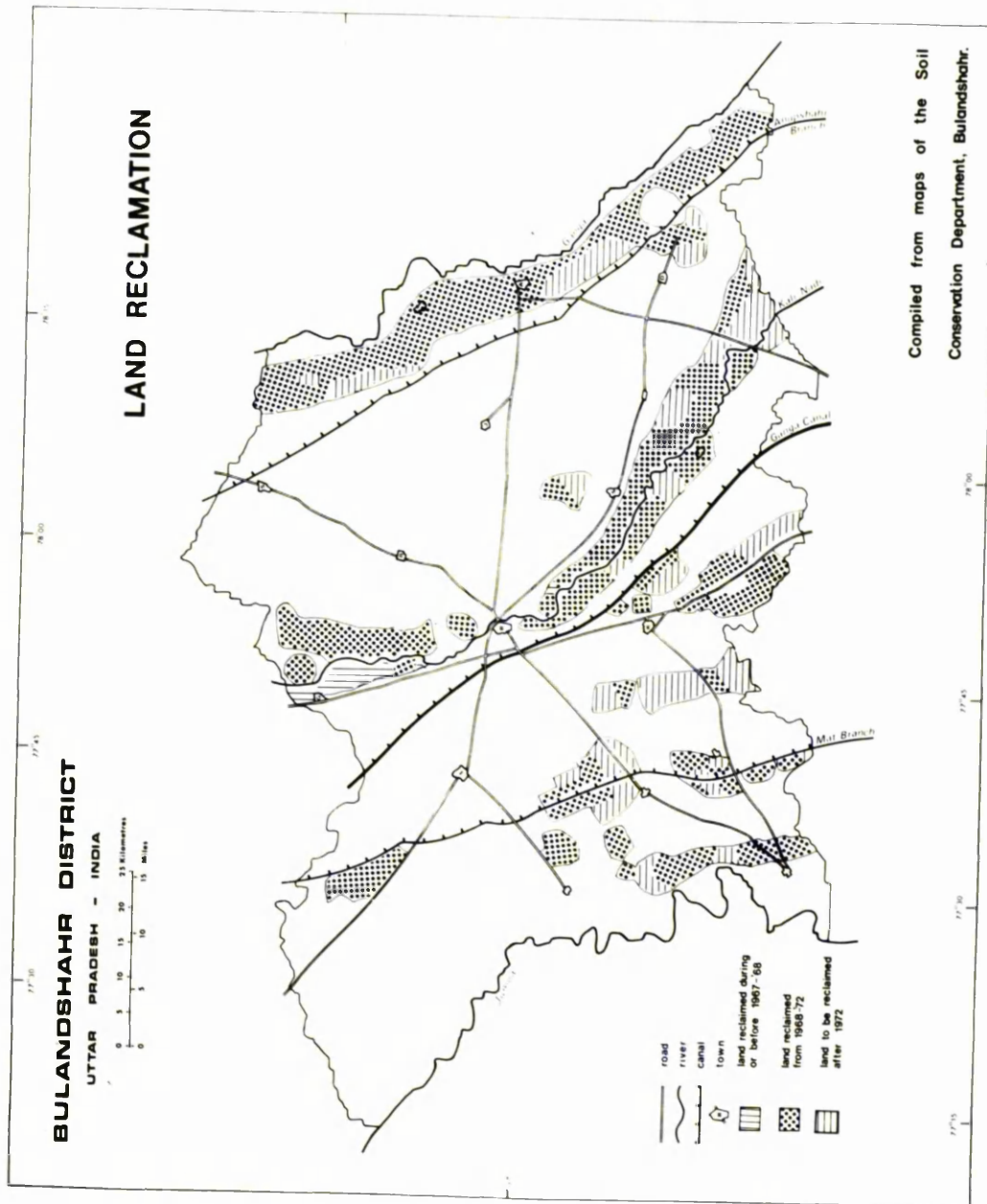


Fig. 3.24

a day, and from April to June, from four to eight hours a day (53). Electricity shortages mean that the effectiveness of the present irrigation facilities is much impaired by the inadequacy of the power supply.

Irrigation water, however, has been a mixed blessing in Bulandshahr district and in the doab. Without water, agriculture could never have progressed in western Uttar Pradesh to the extent it has done. As the irrigated area has increased, however, capillary action has brought to the surface the soluble and partly soluble saline and alkaline compounds in the soil. These excess soluble salts are for the most part the cations of sodium, calcium and magnesium and the anions chloride, sulphate, bicarbonate and to a minor extent carbonate (54). According to the soil conservation officer of Bulandshahr, C.S.Sharma, the soils of the district tend to be more alkaline than saline and the removal of the sodic ion is one of the greatest problems in the affected areas (Fig.3.24). The growing volume of irrigation water has increased surface run off and with more moisture in the surface soil the upward movement of dissolved salts by capillary action has been intensified, and the quantity of saline and alkaline efflorescence has increased proportionately. Under such conditions the soil surface frequently becomes hard when dry and loses any distinct structural profile other than a puddled surface that shrinks and cracks on drying (55). Concentration of salts in the root zone can have an adverse effect on plant growth, particularly at the germination stage (56).

In the early part of the twentieth century, the water-table

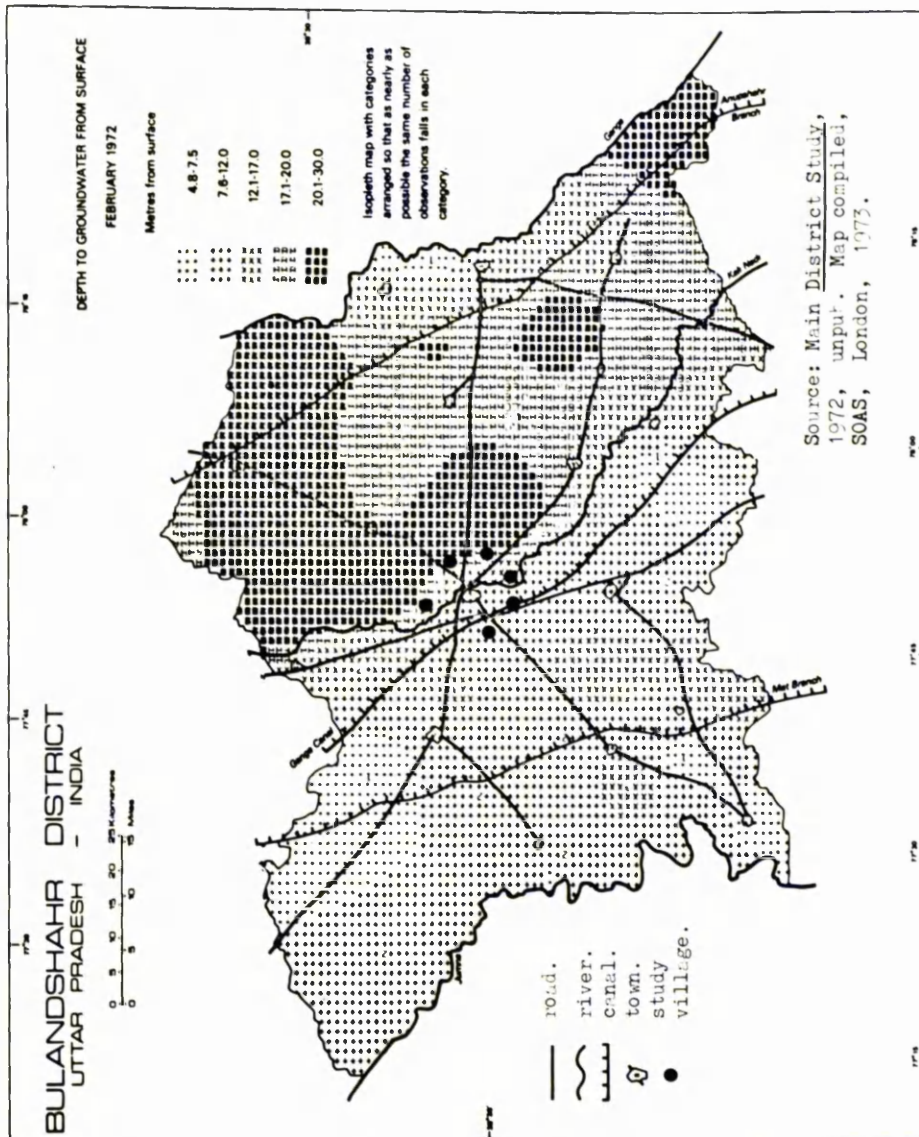


Fig. 3.25

level was as little as two metres below the surface (57). It has fallen since then, and Fig.3.25 compiled from data collected by the District Study shows the water-table level in Bulandshahr district in 1972. The problem began shortly after 1855 when the water was first taken from the canals. In the Settlement Report of 1865, Currie, the settlement officer, complained about the loss in revenue from the Kali Nadi lowlands (58) where the water-table had risen so much that farmland was put out of production. Following the complaints from the settlement officer, the canal department was forced into clearing and increasing the capacity of many of the district's streams. The high water-tables may also have been the result of several 'wet' years. The panic abated when the level of the water-table fell. Fig.3.25 shows the present level of ground water in the district, and indicates that the canal irrigated tracts in the west of the district have very much higher ground water levels than the areas to the east of the Kali Nadi. Injudicious use of canal water, and inadequate drainage, have led to this situation and have aggravated the naturally occurring 'reh'¹ deposits. The regulation of the surface and sub-surface water resources is extremely important in the long term agricultural development of the district, although those who have responsibility for the direction of such development are more usually interested to implement schemes which promote short term changes. The undesirable inheritance from the canal era, of much land sterilized by water-logging and related reh conditions, emphasizes the difficulties which attend un-regulated water resource development.

1. Reh - saline efflorescence, crystallized in the dry season on the surface and in the upper horizons of salt-affected soils.

Positive efforts are being made by the Uttar Pradesh soil department to reclaim land which has been put out of production by water-logging. These areas where reh deposits are heaviest occur most frequently near the streams and canals in Bulandshahr district where the water-table rises. Fig.3.24 shows the affected areas and the areas that have been reclaimed in Bulandshahr district both before and after 1965-66. Government plans to increase the area under cultivation have been largely responsible for the increase in recent land reclamation schemes. A Central Soil Conservation Board has been in existence since 1953 (59), but positive measures to conserve and reclaim land were only made in the early years of the third five year plan (1961-65) and have been given considerable support since the High Yielding Varieties Programme was introduced in 1966.

The gradient of the land in most parts of Bulandshahr district is almost negligible and the most common methods of land reclamation such as terracing and the construction of elaborate drainage channels is of little value. In the majority of cases the land is treated with gypsum and sulphur (60). A high proportion of the reh deposits consist of sodic compounds, often sodium bicarbonate, which give the soil an alkaline reaction. In a fine textured soil these compounds are largely responsible for the formation of a crust on the soil surface which inhibits drainage and plant growth. Sodium is a loosely held metallic ion and is readily displaced when gypsum (calcium sulphate) sulphur and sufficient water are added to the soil. The calcium ions replace the absorbent sodium and this in turn is removed from the soil in the percolating waters as sodium sulphate(61).



Plate 9.

Wheat fields affected by water logging and deposits of reh
on the soil surface.

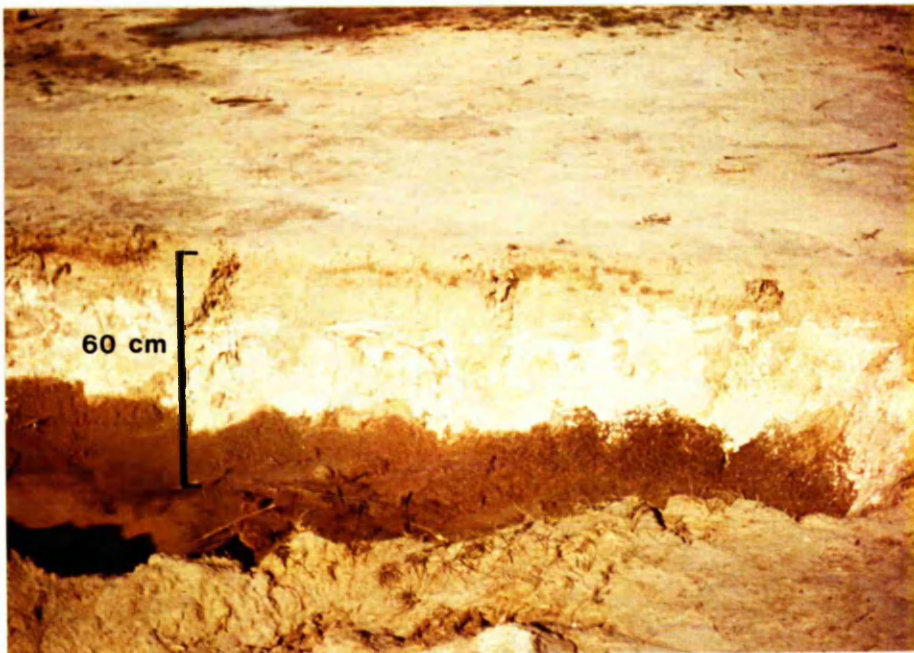


Plate 10.

Soil profile showing the accumulation of saline and
alkaline compounds in the surface layers of the soil.

Source: Field work for the Wheat Study - March 1972.

Major chemical changes involved in the reclamation of
a soil with a strong alkaline reaction.

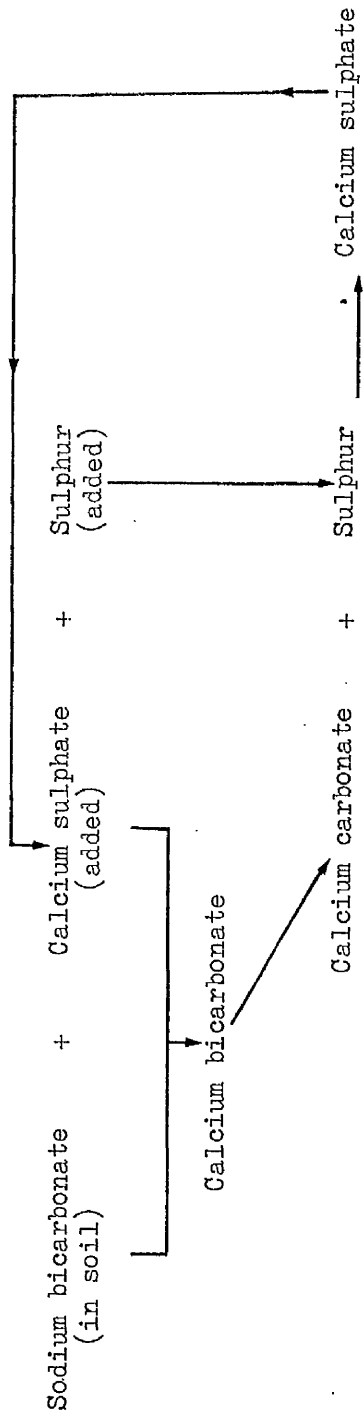


Fig.3.26

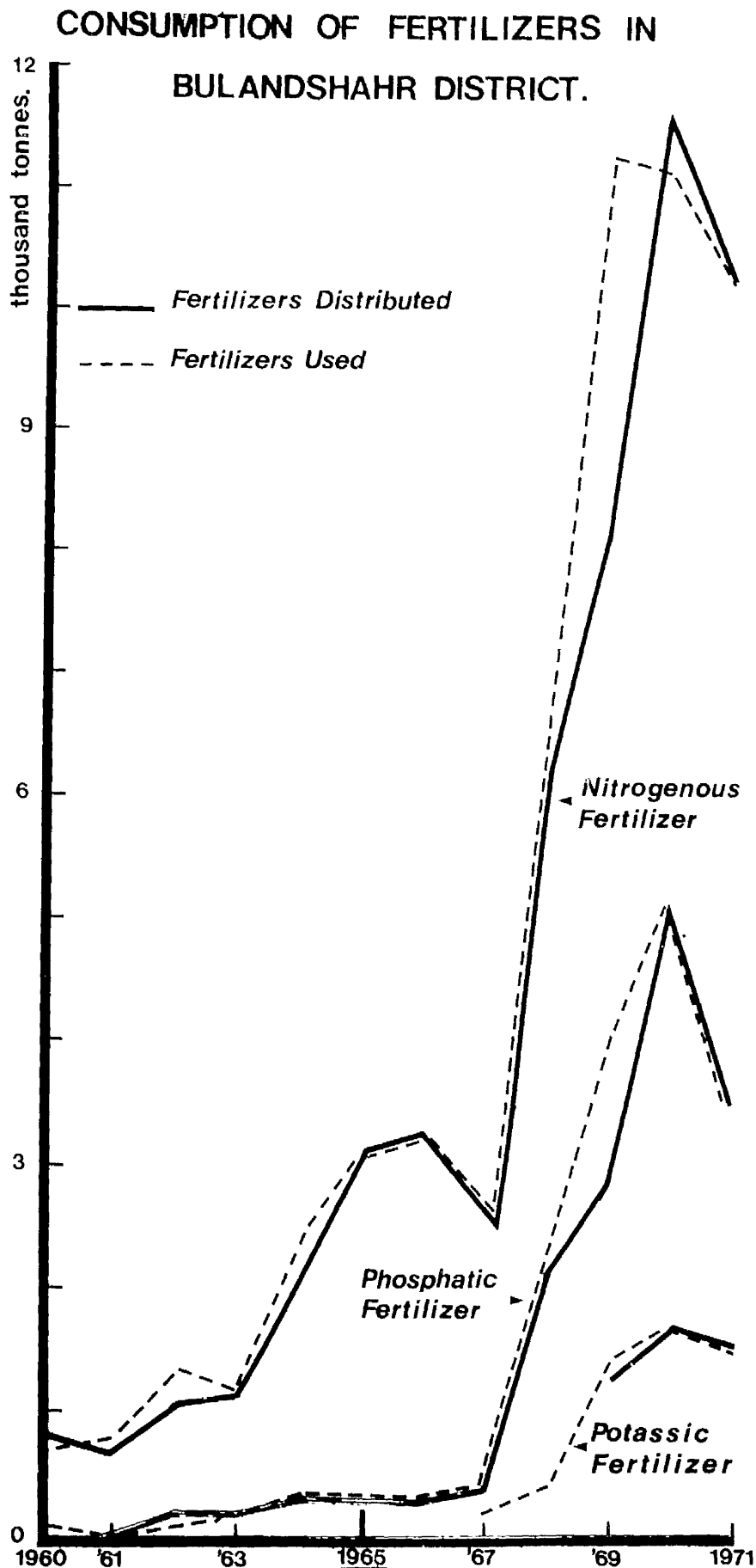
The purpose of adding sulphur is to prolong the cation exchange process which takes place during reclamation. While the sodic ions are being leached from the soil, the sulphur is rapidly oxidized to calcium sulphate by the displaced calcium ions and with the re-formation of calcium sulphate, further cation exchange can take place and more sodium in the form of sodium sulphate can be leached down to the lower layers of the soil (62). This reaction is shown in diagram form in Fig.3.26. The improvement both in the physical and chemical conditions of the soil may eventually bring the land into profitable production, but the process may take several years and be of great expense as periodic treatments with gypsum and sulphur may be necessary to ensure that the land remains productive.

According to the soil conservation officer of Bulandshahr, Mr.C.S.Sharma, gypsum and sulphur are the most commonly used chemicals for usar¹ land reclamation, where other methods such as heavy green manuring have failed. These chemicals are usually applied during a break in the monsoon rains. Embankments half a metre in height and of equal width are built in the pattern of a grid across the land to be reclaimed. The fields are flooded and as the water evaporates the land cracks to depths often below the level of the kanker² pan and the soluble salts, many of which are injurious to plant growth, are deposited on the surface as a result of capillary action (63). The surface of the

-
1. Usar - unproductive soil containing saline and alkaline compounds sufficient to inhibit the growth of crop plants.
 2. Kanker - Calcareous rubble, found abundantly in alkaline tracts; used in road building.

soil is then treated with the gypsum and sulphur and the monsoon rain leaches the salts down to the levels below the plant root zone. Any vegetation that appears is protected from grazing, and in the second year of reclamation, a crop such as Crotalaria juncea may be planted and then ploughed into the land at the flowering stage, a process which helps to increase the nitrogen content of the soil (64). With successive treatments such as this, badly affected usar soil can be reclaimed, but, once suitable for farming, its condition has to be maintained as a reversal of the situation is highly probable.

The work of the State Soil Conservation Department is severely limited because of the expense and problems of obtaining the raw materials necessary for reclamation of land affected by water-logging. While a slow but concerted effort is being made to bring sterile, water-logged land under cultivation, the fertility of farm land is being maintained by the increased use of chemical fertilizers. The growing importance of fertilizers in Bulandshahr district will be discussed in the next section.



Source: Effective Demand for Fertilizers in India, (unpub.)

Ministry of Agriculture & IBRD - 1972.

Fig. 3.27

4. Changes in the patterns of fertilizer use in
Bulandshahr District.

During the mid 1960s, India received loans from the United States to finance imports of fertilizer (65). At the same time, America and the World Bank put great pressure on the government to encourage multi national corporations to invest in local production capacity (66). In 1965-66, the pressure on fertilizer sources was only just beginning. Fertilizer becomes more essential as the number of crops taken per year increases, and according to Brown,

".... once it becomes profitable to use modern technology, it is only the agri-business firms that can supply these demands efficiently."

(67).

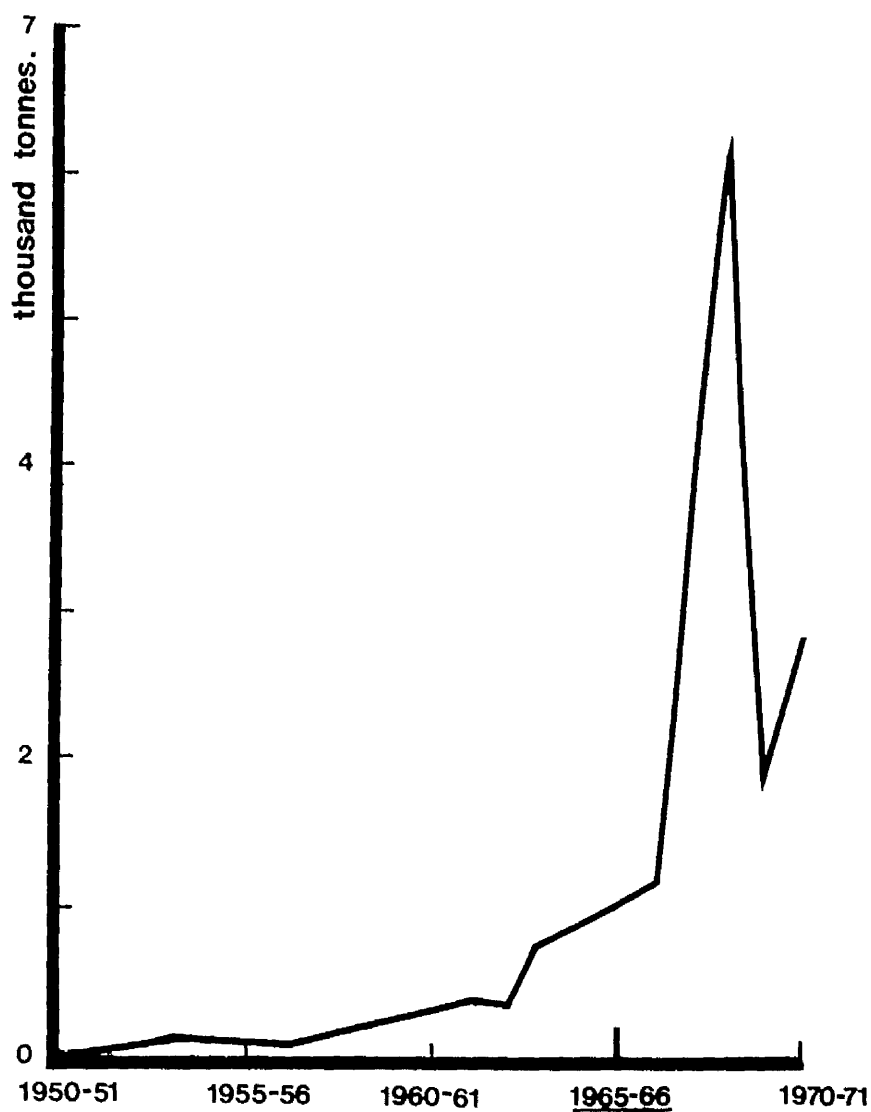
Fertilizers containing nitrogenous, phosphatic and potassic compounds are of the greatest benefit to the soil. Fig.3.27 shows the consumption of these in Bulandshahr district since 1959-60. The rise after 1966-67 corresponds with the period when the new wheat seed became popular. The decline in the curves of fertilizer distribution and consumption by 1971, by approximately ten per cent of the volume used the previous year is difficult to explain. Farmers complain of fertilizer shortages, and the supply problems explain to some extent the reduced consumption.

Despite this fall, the amount of sodic, phosphatic and potassic fertilizers used was far higher in 1971-72 than in the mid 1960s, and is consistent with the changes which should

accompany the adoption of new high yielding varieties.

Unfortunately no data are available to suggest which crops receive fertilizer, but the change in pattern of fertilizer use coincides with the years of introduction of the new high yielding varieties closely enough to suggest that the fertilizer is being used for these new hybrid crops.

**TOTAL CONSUMPTION OF CHEMICALS
USED FOR PLANT PROTECTION IN U.P.**



Source: 24 Years of Plant Protection in U.P.
Ministry of Agriculture - 1971,
Delhi.

Fig. 3 . 28

5. Changes in the patterns of pesticide use in
Bulandshahr District.

District level statistics for pesticide use were not available for Bulandshahr, but data for the whole of Uttar Pradesh were available (Fig.3.28). Although it is never advisable to extrapolate trends in data, it is none the less interesting to see the marked rise in the use of pesticide after 1966-67. The source material notes that in 1968, the consumption of pesticide was unusually heavy owing to epidemics which attacked large areas of crops (68), and this is reflected in Fig.3.28. Following the pest attacks of 1968, nearly all 'new' seed received by the farmer from government organisations is treated and hence reduces the quantity of pesticide necessary. Farmers are urged to treat their own seed with a four per cent solution of Agrosan GN, a compound with a mercuric base, but great precautions are taken to point out that treated seed is only to be sown and not to be eaten.

There are no data for pesticide use available at district level, so state level data must be used as a substitute. These show that pesticides have come into use much more since the mid 1960s (Fig.3.28). With new seeds, extra precautions are necessary because relatively little is known of the susceptibility to old and new pests. A study of the use of pesticides in Indian agriculture by the National Council of Applied Economic Research, in 1967, showed that farmers were reluctant to use plant protection methods. Their main reasons were ignorance of the value of pesticides and inadequate resources (69). In Uttar Pradesh, 34.00 per cent of the sample claimed that the use of plant protection measures was beyond their means and that they were unable to obtain the necessary credit facilities. Hopefully, the situation

has improved since 1967, when the survey was carried out and as Bulandshahr is an IAAP district and one of the foremost in the state with respect to the adoption of the new varieties, it is likely that patterns of pesticide consumption are at a higher level per hectare than those reflected in the state level statistics. Both new and indigenous varieties benefit from the use of pesticide, a situation which contrasts with that of fertilizer, where it is mainly the new varieties which benefit from the use of chemical fertilizer.

3.4. Conclusion.

This chapter has served two purposes. First, it is a description of Bulandshahr district as a whole and so puts the Wheat Study area in its context. Second, it has highlighted the importance of wheat to the farmers and so shows the relevance of the Wheat Study to the area. The published statistics used in this chapter have shown that farmers of the district are adopting the new high yielding varieties and some of their related inputs, but unfortunately, relatively little detail is available on their innovation and diffusion patterns since the new seed was introduced to the district. It should be noted that the patterns of innovation and diffusion are not spatial patterns, since it was not possible to arrange a sufficiently large sample to cover this aspect.¹

The next chapter examines in some detail the patterns of adoption of the new varieties within the Wheat Study area, in an attempt to discover which farmers were the first to innovate and what factors have persuaded farmers to experiment with the new seeds. The discussion relating to 'patterns of diffusion' deals with the extent to which farmers in the various villages, castes and farm types (i.e. irrigated or non-irrigated, according to farm size, and the level of education of the farmer), have adopted new seeds and farming methods since 1965-66.

1. The main District Study was concerned with spatial considerations, and villages in all parts of the district were enumerated in this connection.

CHAPTER 4.

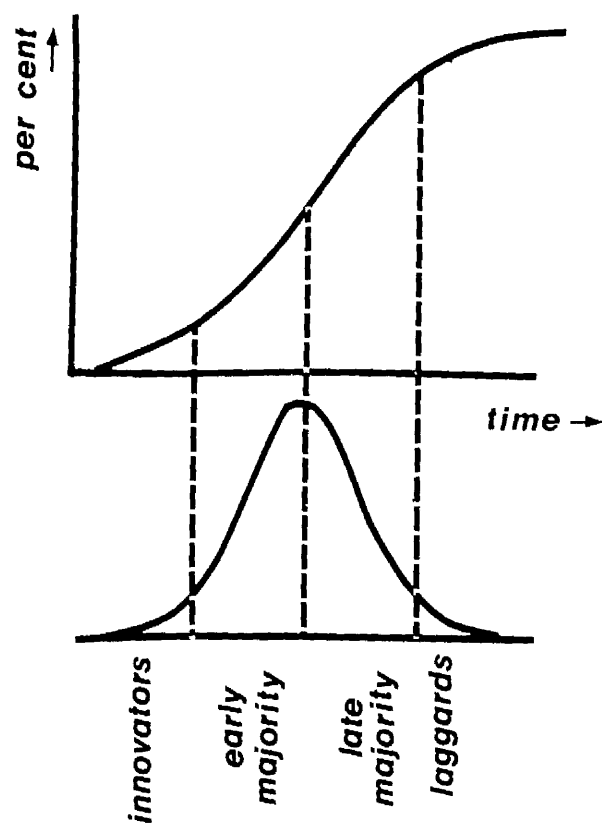
The rates of adoption of high yielding varieties of wheat in the study area.

4.1. Innovation and diffusion models and the rate of adoption of the high yielding varieties of wheat in the study area.

The importance of wheat farming in Bulandshahr district was established in Chapter 3, so we are now in a position to move on to test the first claim of the null hypothesis (Chapter 2.p.59) that 'there have been no significant changes in wheat farming patterns in the study area since the introduction of the new high yielding varieties'. The answers to the questionnaire firmly rejected this claim, as by rabi 1971-72, 97 per cent of the cultivators enumerated for the Wheat Study were sowing dwarf wheat. The 1972 District Study confirmed the high level of adoption of the new varieties when 95 per cent of the farmers for enumeration stated that they were growing these varieties. Unfortunately, no comparable data were available from government sources for the district, as until 1970, when Bulandshahr became a member of the Intensive Agricultural Areas Programme, (IAAP), government statistics made no distinction between the areas sown to dwarf and indigenous wheat varieties.

As there has been a change from traditional farming patterns with the spread of the new varieties, the purpose of this chapter is to examine in detail patterns of adoption of dwarf wheat and to see how far they compare with the results of other innovation and diffusion studies. The process of diffusion of ideas and information takes place in both spatial and temporal dimensions. In order to examine spatial patterns of diffusion throughout the district, the Wheat Study area would have to be considerably

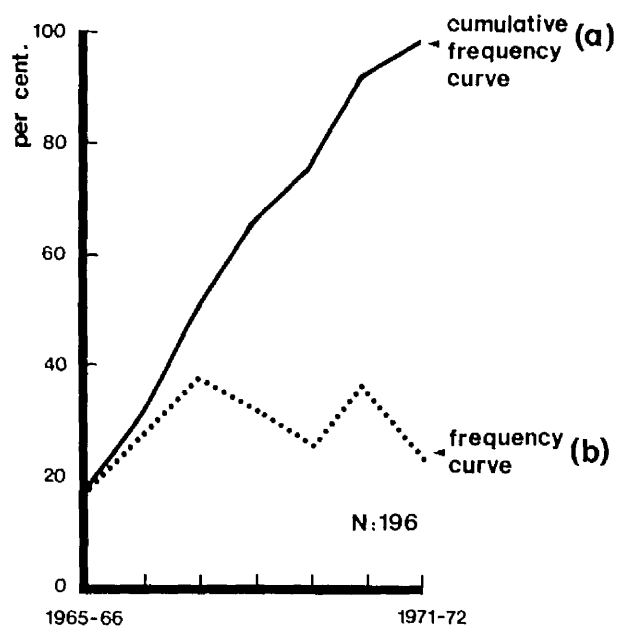
THE RELATIONSHIP BETWEEN THE THEORETICAL
'S' SHAPED INNOVATION CURVE & THE NORMAL
FREQUENCY DISTRIBUTION.



Cumulating the distribution of
innovation acceptors.

Fig. 4.1

DIAGRAM SHOWING THAT THE ADOPTION CURVE FOR 'NEW' WHEAT IN THE SAMPLE AREA DOES NOT COMPARE CLOSELY WITH THE THEORETICAL 'S' SHAPED CURVE OF ADOPTION.



Source: Field work for the Wheat Study - March 1972.

Fig. 4.2

larger so that patterns could be examined with reference to the position of Bulandshahr, which is probably the node from which agricultural information is disseminated throughout the district.

All six study villages were within 16 km. of Bulandshahr, and so it seemed of greater value to examine patterns of adoption over time. Each cultivator was asked to recall the year in which he started to grow either the pure Mexican strains, or the Mexican Indian hybrids, as both of these were classed as 'new wheat' in the Wheat Study (Appendix 2.1.). The results of the study were examined in the light of diffusion models used by Rogers (1962)(1), Morrill (1968)(2), Hagerstrand, (1968)(3), Haggett, (1972)(4) and Brown (1968)(5). Rogers shows that there are five stages in the process of adoption of an innovation. These are awareness, interest, evaluation, trial and adoption (6). It is the progressive element of the population, usually a small minority who experiments with the innovation, and if it proves a success, the step from the awareness to the trial and adoption stages that Rogers has noted, takes place more rapidly among the majority of the community. The adoption rate then declines as the remaining few laggards progress from the evaluation stage to trial, and finally adoption of the innovation. When the diffusion process of an idea or of any material item is expressed by accumulating the percentage of adopters over time, the result is an 'S' shaped curve (Fig.4.1).

The adoption rate of the new high yielding varieties in the study area was plotted (Fig,4,2), but the cumulative frequency curve did not compare closely with an 'S' shaped curve. The curve for the study area did give one the impression that the

'toe' had been lost and that it seemed likely that in the period before 1965, the rate of adoption might have been more gradual and in keeping with the period of 'trial' of the innovation by the progressive minority suggested by Rogers (1962)(7).

It must be stressed that lack of information prior to 1965 is not merely an omission in the data collection programme. Data on adoption of the dwarf varieties were not collected earlier than 1965 because it was in that year that the 'new' wheat was officially released to the cultivators. The absence of an initial period when the gradient of the curve was gentler may be due to one of three reasons. First, data collected prior to 1965-66 may have added the missing 'toe', for although the new varieties had not been officially released, it is quite likely that as a result of distribution through irregular channels, the seeds were being sown by an enthusiastic minority. If this was the case, a section could have been added to the curve where the slope was gentler and this would have given it the main properties of the innovation curve, where an initial period of gradual adoption was followed by stages of more rapid, and finally declining adoption. Little information could be obtained from the cultivators on the source of dwarf wheat prior to 1965. Some who may have obtained seed on the black market were wary about providing the necessary information, and so rather than cause embarrassment and sometimes hostility which could have adversely affected the survey, the subject was not pursued.

The second reason for the absence of an 'S' shaped curve after 1965-66 might well have been that the information network

about the new varieties had been widespread and so had led to a high level of demand for the new seeds. This is not improbable as the cultivators in the area had long since been accustomed to the periodic introduction of improved indigenous varieties and were always ready to try a 'new variety' as soon as it was released. This might explain the absence of a period of trial and experimentation by the minority. From informal discussions with local officials at the district level, it was clear that one of the main constraints on the adoption rate was the availability of seed. Apparently, the cultivators had always been prepared to experiment with the new varieties, and supplies of seed had been short from the time of their introduction in 1965. This has probably caused a modification of the theoretical 'S' shaped curve of adoption and resulted in the curve constructed for the study area (Fig.4.2).

Even if the 'toe' of the curve was present, the next question is, would the curve of innovation adoption in the study area be 'S' shaped? A subjective definition of an 'S' shaped curve is that at the beginning and end of a successful innovation the gradient of the curve is low, and between these periods is a space of time when adoption of the innovation is relatively rapid, thereby producing a steep gradient. This is not sufficiently precise, and it was felt that one method of deciding whether or not the innovation curve constructed from the Wheat Study data was truly 'S' shaped, was to compare it with the theoretical innovation curve. This theoretical innovation curve is the plot of the cumulative frequency curve of a normal distribution (Fig.4.1), and so the easiest method of deciding whether or not the adoption rate curves in the Wheat Study data compared with the 'S' shaped curve, was to examine them as frequency distributions which had

MODIFICATIONS OF THEORETICAL INNOVATION
CURVES.

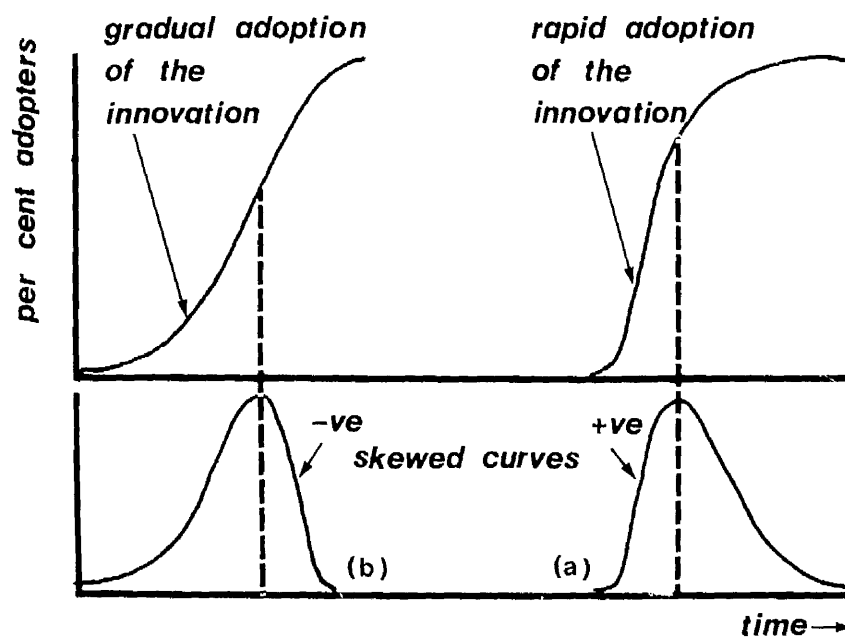
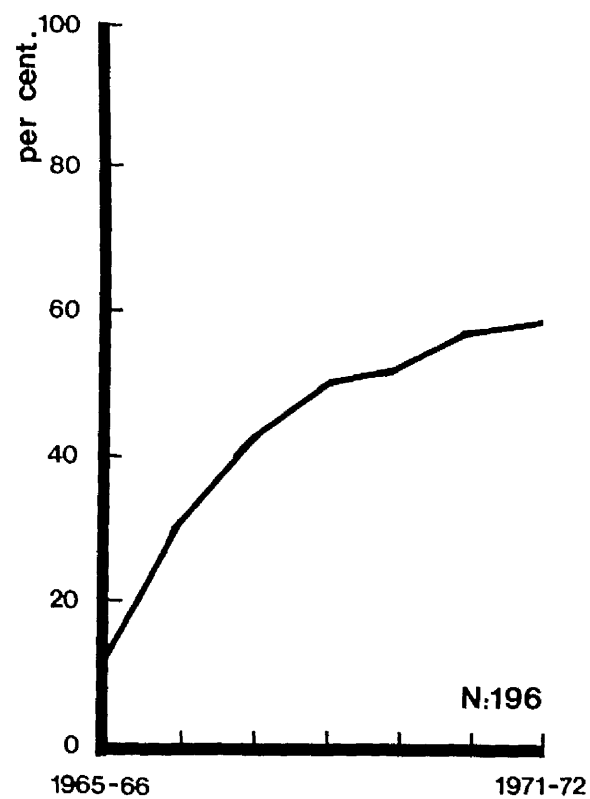


Fig. 4.3

INCREASE IN THE PROPORTION OF FARMERS
WHO RECEIVED INSTRUCTION IN WHEAT FARMING.



Source: Field work for the Wheat Study - March 1972.

Fig. 4.4

not been accumulated, and to see if they compared statistically with a theoretical normal frequency distribution, in which the mean and standard deviation were the same as the frequency distribution constructed from the study data.

One could argue that this particular method of testing for an 'S' shaped innovation curve is suitable only if the curve is symmetrical as it is in Fig.4.1. If however, the 'S' shape is distorted, as it probably will be in a 'real world' situation, and if the initial adoption period has been more rapid than the decline, (Fig.4.3a), then a positively skewed ~~normal~~ distribution will result when the curve is plotted in its non-cumulative form. If the converse is true, and the initial period of adoption is very gradual, the non-cumulative form of the innovation curve will be negatively skewed (Fig.4.3b). In neither of these two cases would the 'S' shape of the innovation curves be symmetrical and so, on both occasions their respective non-cumulative frequency distributions would differ significantly from normality. Throughout this chapter wherever such curves were observed to be unimodal, an attempt has been made to examine the skew of the curve in a formula comparing the mean and the median of the distribution.¹

Every non-cumulative innovation curve has been compared by the chi square test with the normal distribution,² to confirm observations that the majority differed from it. It was only

1. The test for skewness was taken from Blalock, H.M., 1960, Social Statistics, New York, p.74.

2. The method of comparing observed and theoretical frequencies was taken from Blalock, H.M., op. cit. p.240.

those curves which differed least, in the statistical sense, from the normal distribution that were examined for skewness. The test was of little value if the curve was not unimodal. The test involving the difference between the mean and the median was used, as this index is directly related to both the degree and distribution of skewness, and so it shows how close these unimodal curves were to the normal distribution. By testing for both normality and skewness in selected unimodal curves, it was possible to estimate how closely the data followed the 'S' shaped innovation curve, and to explain possible reasons for modifications of the theoretical model.

Fig.4.2b shows the frequency distribution of adopters of new wheat in the study area in its non-cumulative form, and when compared with a theoretical normal frequency distribution with the same mean and standard deviation, the chi square test showed that there was no statistically significant relationship between the two distributions. As the gradient in the cumulative adoption rate curve did not increase at a constant rate, the result was that the non-cumulative frequency distribution was bi-modal, so indicating inconsistent adoption of the new wheat varieties within the study area.

Having examined the adoption rate curves (Fig.4.2a and b) of new wheat in the study area, both by subjective discussion and more precise statistical means, inconclusive results suggested that more insight into the data might be gained if they were examined at a different scale. The inconsistent gradient of Fig.4.2a prior to 1970 which resulted in the bi-modal nature

nature of Fig.4.2b', led one to suspect that there were groups of innovators within the Wheat Study area performing at different rates, which meant that when data for the study area were treated as a whole, no clear innovation patterns were apparent and the results were inexplicable.

Returning to the categories of farmers introduced in Chapter 2, data were divided according to the statistically 'independent' variables (p.66) which, in the field had seemed capable of influencing decisions made by the wheat farmers. The adoption rate of dwarf wheat by cultivators grouped according to their village, caste, education level, farm size, year of instruction and main sources of irrigation, were examined (Chapter 2. p.71), and at these scales, approximation to the 'S' shaped curve of adoption was much greater than when the entire study area was considered as a whole unit.

Although accumulated adoption rate curves did not approximate more closely to the theoretical innovation curve than did the curve for the entire Wheat Study area, none was found to be truly 'S' shaped when the non-cumulative frequency distribution was compared with the normal curve by the chi square test.

By fitting empirical data to the theoretical patterns, one hopes to be able to predict conditions within the study area, in this case, the nature of the adoption rate curve. It was clear from looking at the data that there was no precise pattern in the forms of any of the innovation curves, but an ordering of

the material was present. For instance, one could say that the higher castes, the Jats and Rajputs, usually adopted the new varieties earlier than did the Muslims¹ and Chamars, and the 'large' farmers adopted the new varieties earlier than 'smaller' farmers; the categories of 'large' and 'small' will be defined in the detailed section later in the chapter. (pp. 160-163).

The irregular gradients of some of the overall sample cumulative frequency curves and the absence of the unimodal distribution in their non-cumulative form, suggested that the data needed to be examined at an even more detailed level where cultivators were part of identifiable social groups with strong internal communication flows. In order to examine the importance of these groups, the cultivators were subdivided yet again according to their caste groups within the villages. Perhaps the most informative material on patterns of innovation within the study-area were derived from these groups (pp. 177-186).

The purpose of this introductory section has been to put the contents of this Chapter in perspective and to show the importance of scale in the study. With this awareness of the importance of scale, the data will now be analysed at the scale of six statistically 'independent' variables which seem likely

-
1. Muslims - When asked in the questionnaire survey, several farmers referred to their caste as Muslim. Even though Muslim is the name given to a follower of Islam, and is not a Hindu caste, after long association, Muslims have come to occupy a position in the Hindu caste hierarchy. During the field work I found that the word Muslim had both a social and a religious meaning, and so it was included in the caste groupings of the Wheat Study.

to have a direct influence on decisions of the farmer to innovate.

The six variables are:-

1. The year of instruction in new methods of wheat farming.
2. The education level of the farmer.
3. The size of the area farmed.
4. The number of irrigation sources of the farmer.
5. The village identity of the farmer.
6. The caste of the farmer.

Unfortunately, the close linkages between these variables (Appendix 4.) make it impossible to calculate the precise effect of the 'independent' variables on the rate of adoption, which is the statistically 'dependent' variable in each case. It should be noted that many of the variables have been measured at nominal or ordinal level only, and are therefore not suitable for analysis by high powered statistical techniques. Non-parametric techniques have been used throughout this chapter, and although lower powered, they do indicate the presence or absence of a significant relationship between each of the 'independents' and the 'dependent' variable. The effect of the selected members of the group of 'independent' variables on the patterns of wheat farming will now be examined in an attempt to answer the question posed through the null hypothesis, that wheat farming patterns within the study area have not altered significantly since the new varieties were introduced.

- 4.2. The relationship between the rate of adoption of dwarf wheat in the study area and selected independent variables.
- 4.2. The relationship between the rate of adoption of dwarf
- i. The relationship between the year of instruction in the new farming technology and the rate of adoption of the new wheat.

The first variable which seemed likely to influence the adoption rate of the new varieties in the study area as a whole, was the year of instruction in the new farming technology. Farmers who were taught the benefits and methods of growing the new wheat varieties soon after their introduction to India, might well have been the first farmers to adopt them. This argument was examined by asking farmers if, when and from whom they had received instruction on the new methods of wheat farming. Out of 196 farmers in the sample, only 114, or nearly 61 per cent, had received any form of instruction. Fig.4.4. illustrates the increase in the proportion of farmers who obtained information from any of the listed sources, (Appendix 2.1). The largest number of farmers received instruction in new wheat farming techniques in the rabi season of 1966-67, and the main source of information was the extension agent, the village level worker. Fig.4.5. summarizes the various sources from which the farmers received instruction.

Table showing the proportion of farmers who received instruction in new methods of wheat farming from the main sources by rabi 1971-72.

| <u>Source</u> | <u>Proportion of farmers</u> | <u>Number in each group</u> |
|---|------------------------------|-----------------------------|
| 1. Friends | 7.02 per cent | 8 |
| 2. Block officials or the Agricultural College. | 19.30 | 22 |
| 3. Village level extension workers. | 73.65 | <u>84</u> 114 |

Source: Field work for the Wheat Study March 1972.

Only 61 per cent of the farmers received instruction on the methods of wheat growing, and there appears to be no significant relationship between the rate of adoption and the year in which farmers received instruction.

App.4, pp.480-490 considers the inter-relationships between the year of instruction and other 'independent' variables on a more detailed scale such as, the village identity, caste and the size of the area farmed. First, at village scale, a far greater proportion of the farmers in the three villages of Akhtiarpur, Manakpur and Chirchita had been instructed on the new farming techniques, than in the other three villages (Appendix P.489). These three villages with the better informed farmers were mainly irrigated by tube wells. According to Mr.B.B.Lal, the acting Block Development Officer (BDO.) in Bulandshahr in 1972, these irrigation facilities had been introduced since 1965-66 to supercede a previously disadvantageous situation with respect to water resources. Farmers without access to the Ganga canal system, and with no reliable irrigation source are being encouraged by extension workers to develop their own source of irrigation, as the high yielding varieties cannot be grown successfully where dry farming is practised. The BDO. confirmed that extension work is being concentrated in the non-canal irrigated villages, as these villages have been far less privileged than canal villages until the recent developments in tube well irrigation.

The three tube well villages do show a marked increase in the number of adopters of high yielding varieties after 1966-67, but the pattern does not differ significantly from the villages

which have received less attention from the extension workers, according to the Kruskal-Wallis analysis of variance test. In every village the farmers were prepared to experiment with the new dwarf varieties before they received any formal instruction, but there is no statistical evidence from the data, to suggest that formal instruction had any significant effect on the rate of adoption of the new varieties of wheat. Whether or not instruction affected the techniques farmers used for their new high yielding varieties, will be considered in Chapter 6. Having examined patterns of instruction in new wheat farming at the village level, the second inter-relationship to be examined was between the year of instruction in the new farming techniques and caste.

Table to show the proportion of the major caste groups receiving instruction each year.

| Number in each group. | Caste group | 1965 - 66 | 1966 - 67 | 1967 - 68 | 1968 - 69 | 1969 - 70 | 1970 - 71 | 1971 - 72 |
|-------------------------------|----------------|-------------------------|--------------|--------------|--------------|--------------|--------------|-----------------|
| 76 | I | <u>46.20</u> | <u>52.71</u> | 33.00 | 35.70 | | 10.00 | <u>per cent</u> |
| 48 | II | 23.17 | 21.20 | 37.56 | <u>66.66</u> | <u>75.00</u> | | |
| 65 | III | 23.17 | 18.41 | 25.00 | 7.25 | 25.00 | <u>90.00</u> | |
| 7 | IV | Inadequate sample size. | | | | | | |
| <u>Chi square values.</u> | | <u>16.3</u> | <u>26.7</u> | 2.1 | <u>19.6</u> | <u>29.6</u> | <u>71.0</u> | |

Double underlined values significant at .1 per cent level.

Members of caste groups:- I.Jats, Brahmins,Rajputs. II.Gujars and Lodhas. III. Muslims, Muslim-Rajputs and Chamars. IV. Other Hindus and Shepherds.

Source: Field work for the Wheat Study - March 1972.

Fig.4.6.

Fig.4.6. shows that the largest proportion of farmers instructed from 1965-66 to 1967-68 were members of caste group I, the Jats, Brahmins and Rajputs. Members of caste group II, the Lodhas and the Gujars were next to receive instruction, while the largest proportion of farmers instructed in new farming techniques as late as 1970-71, were members of caste group III, the Chamars, Muslims and Muslim-Rajputs. These observations were confirmed by the chi square test for 'K' samples. A comparison was made between the number of farmers who received instruction in each year, and the resulting chi square values have been included in Fig.4.6. Unfortunately the level of measurement of the data is too low for this to be tested by non-parametric multivariate techniques. It would be interesting to test for a partial correlation between caste and a single index for the rate of adoption, taking into account the effects of the year of instruction, as it would provide an indication of the strength of the indirect relationship between these two variables, but adequate data were unavailable. In their absence, however, the conclusion must merely be that there is insufficient evidence to decide whether or not this 'independent' variable has any significant direct effect on the patterns of adoption of the high yielding varieties. Indirect effect through 'caste' and 'village identity', for example, could well be of importance in influencing the rate of adoption of the new varieties.

- ii. The relationship between education levels of the farmers and the rate of adoption of the new high yielding varieties of wheat.

A second factor which seemed likely to influence the decision of the farmer to innovate would be his education level. Perhaps the better educated cultivator would be more willing to experiment with new farming techniques in an attempt to progress. This idea was examined in the study area where 79 of the 196 sample farmers had received some form of education. Of these only 18 had progressed beyond primary school. Fig.4.7. shows the proportion of adopters of new wheat since 1965. The apparent differences in the rates of adoption by educated and uneducated farmers were confirmed when they were examined by the chi square test. (chi square =25.71, significant at the .1 per cent level of probability). The majority of farmers who had some form of education had started to sow dwarf wheat by 1968. After this the rate of adoption decreased.

Table to show the proportion of educated and uneducated farmers sowing dwarf wheat each year.

| <u>Year</u> | <u>Percentage of dwarf wheat growers.</u> | |
|-------------|---|--------------------|
| | <u>Educated</u> | <u>Uneducated.</u> |
| 1965 | 1.26 | 0.87 |
| 1966 | 24.05 | 11.30 |
| 1967 | 45.56 | 25.22 |
| 1968 | 73.14 | 36.52 |
| 1969 | 86.07 | 50.43 |
| 1970 | 91.13 | 67.83 |
| 1971 | 98.73 | 92.17 |
| 1972 | 100.00 | 97.39 |

Source: Field work for the Wheat Study - March 1972.

The adoption rate for the entire sample of educated farmers continued to increase steadily until the rabi of 1970-71, when it slowed down. This indicates that the farmers who received some education must have been among the earlier adopters, but as the discussion in Chapter 2.p.72 pointed out, education level is not independent of the influence of other variables, predominantly caste, and farm size. Fig.4.8 shows the proportion of farmers in each caste who received some formal education and it is clear that more of the 'higher' caste farmers were educated.

Table to show the proportion of educated farmers within each caste group.

| <u>Caste group.</u> | <u>Number in each group</u> | <u>Per cent</u> |
|---------------------|-----------------------------|-----------------|
| I. | 76 | 63.63 |
| II. | 48 | 23.37 |
| III. | 65 | 11.68 |

Source: Field work for the Wheat Study - March 1972.

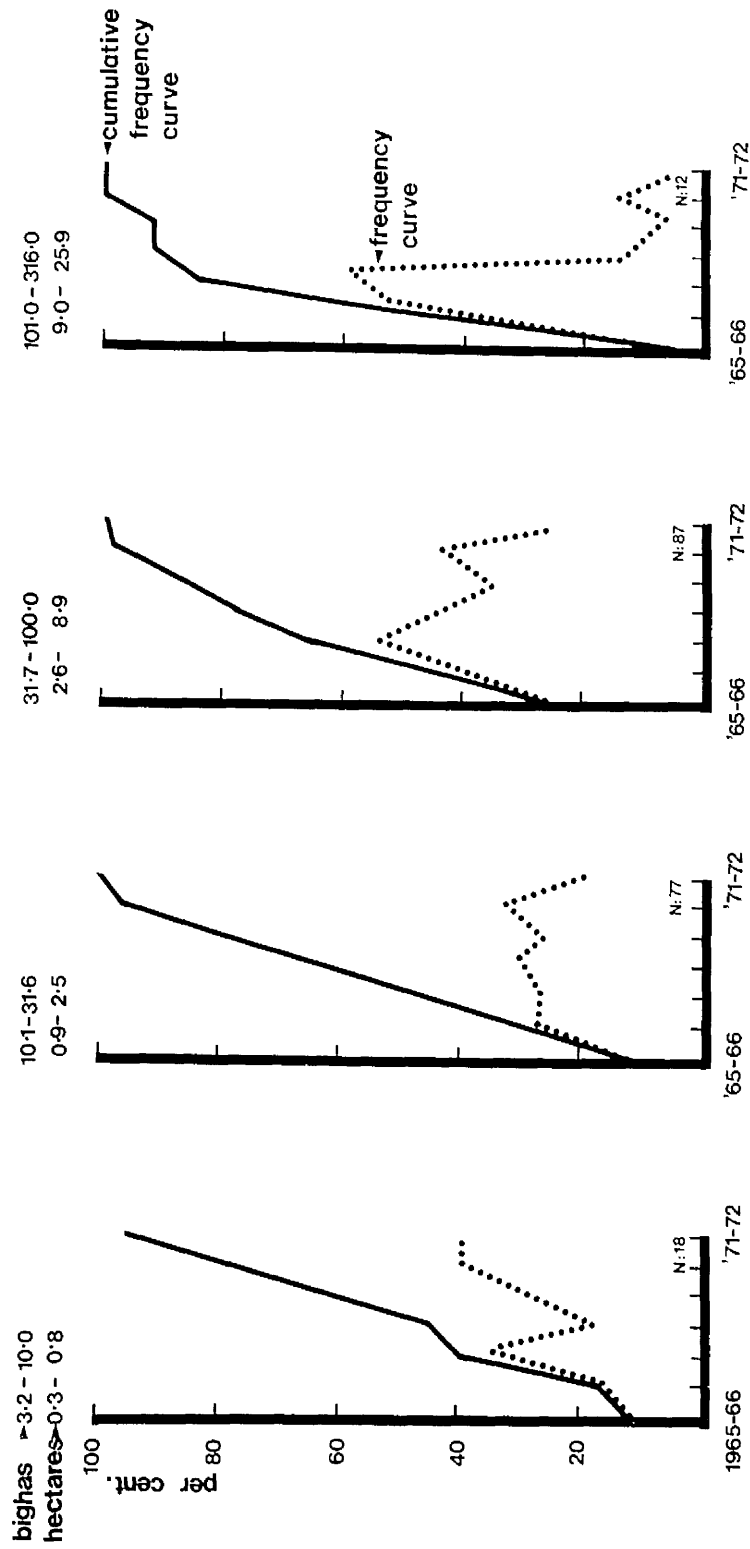
Fig.4.8.

Only two of the 18 farmers who were educated above primary school level were members of caste group II, and there were none in caste group III. 16 of the more educated members of the sample were Jats, Brahmins and Rajputs. This showed quite clearly that it was the higher caste farmers who were the better educated in the study area, and so any relationship between education level and the rate of adoption of the new varieties could be interpreted partly as an indirect influence of caste acting 'through' the variable education.

Now that the possible influence of caste on the relationship between education and the rate of adoption of dwarf wheat has been examined, the link between another statistically 'independent' variable, farm size, and education will next be considered. Only 67 per cent of the farmers who received any form of education, cultivated areas above 32 bighas, (2.59 hectares, one of the divisions on the modified log scale used for holding size)¹. Chapter 2.p. 70 also shows the relationship between caste and farm size. It is the farmers of the 'higher' castes who, on the whole, have the larger farms, and so it can be argued that the caste of a farmer will affect his education directly, while the converse of this is not true. The early adoption rate of the farmers who have had some education quite probably reflects the effect of caste. It is much the same as saying that members of the higher castes were the earlier adopters of new wheat, and the close relationship between these two independent variables, caste and education level, allow the assumption that cultivators who have had some education, and who adopted the new high yielding varieties soon after 1965-66, also have the larger farms and are of higher caste. Owing to their co-linearity (Chapter 2.p. 72) and the direction of the relationship between the variables (Fig. 2.4), it does seem that any explanation for the variation in the adoption rate of the new wheat which is explained by caste, is increased little when the relationships between the other independent variables and the rate of adoption are added. These relationships are largely the indirect influence of caste on the dependent variables.

| | | |
|--------------------|--------------------|----------------------|
| 1. Approximate log | 1.0 - 3.1 (bighas) | 0.1 - 0.2 (hectares) |
| scale for farm | 3.2 - 10.0 | 0.3 - 0.8 |
| size. | 10.1 - 31.6 | 0.9 - 2.5 |
| | 31.7 - 100.0 | 2.6 - 8.1 |
| | 101.0 - 316.0 | 8.2 - 25.9 |
| | above 316.0 | above 25.9 |

PERCENTAGE ADOPTION OF THE NEW WHEAT ACCORDING TO THE SIZE OF THE AREA FARMED.



Source: Field work for the Wheat Study—March 1972.

Fig. 4.9

- iii. The relationship between the size of the area farmed and the rate of adoption of the new high yielding varieties of wheat.

The relationship between the size of the area cultivated and the year of instruction was next to be examined. Fig.4.9 shows the rate of adoption of the new dwarf varieties by the farmers who cultivated areas of different size in rabi 1971-72. The distribution of the farm size observations is highly skewed, with many small farms and few large. A log transformation has been used to arrange suitable categories so that the distribution is more 'normal'. The form of every curve is different and although the characteristic 'S' shape is, to some extent, in evidence, the pattern of the adoption rate curves tend to vary so much that their precise form could not be predicted from any of the 'independent' variables considered so far.¹ Some form of ordering is apparent and Fig.4.9 shows that cultivators with larger holdings did tend to adopt new varieties earlier than smaller farmers. The apparent differences between these curves were confirmed by the Kolmogorov-Smirnov test which showed that each differed significantly from the next.

The absence of the 'S' shaped innovation curve in the relationship between farm size and the rate of adoption is further substantiated by the frequency diagrams derived from the cumulative adoption curves (Fig.4.9). When these curves were compared with normal distributions, each with mean and standard deviation equivalent to the observed frequency curve, the chi square statistics showed that none of the curves was normal in

1. No adoption rate curve has been constructed for farmers with less than 3.1 bighas (0.2 hectares), because the number of cases in this category is too few. The modified log scale was constructed in bighas, one of the local measurements of area, and conversions have been made from bighas to hectares.

its distribution, and that temporal diffusion patterns according to the size of the area farmed did not compare closely with the theoretical patterns of diffusion discussed earlier in the Chapter (p.140).

The data were analysed to see what proportion of the farmers within each of the farm size groups adopted the new varieties before and after 1968-69. This year was selected because it divides equally the length of time that the new dwarf wheat has been grown in Bulandshahr district, up to the end of the study period (Fig.4.10).

Table showing the proportion of farmers with different sized holdings who adopted new wheat before and after rabi 1968-69.

| <u>Bighas</u> | <u>Hectares</u> | <u>Adopters pre 1968-69</u> | <u>Adopters during or after 1968-69</u> |
|---------------|-----------------|-----------------------------|---|
| 1.0- 3.1 | 0.1- 0.2 | 33.33 | <u>66.66</u> (per cent). |
| 3.2- 10.0 | 0.3- 0.8 | 42.00 | <u>58.00</u> |
| 10.1- 31.6 | 0.9- 2.5 | 43.50 | <u>56.50</u> |
| 31.7-100.0 | 2.6- 8.1 | 47.55 | <u>52.56</u> |
| 101.0-316.0 | 8.2-25.9 | <u>90.86</u> | 9.16 |
| above 316.0 | above 25.9 | <u>100.00</u> | 0.00 |

Source: Field work for the Wheat Study - March 1972.

Fig.4.10.

Fig.4.10 shows that there is a definite tendency for the larger farmers to adopt the new high yielding varieties relatively early, but by no means was this true of all the larger farmers. The percentage of adopters pre and post 1968-69 were compared by

the chi square test which confirmed that they were significantly different (chi square = 166.73, significant at .1 per cent level of probability). Lockwood (8) found similar results in Muzaffarnagar, and decided that after the larger farmers had introduced the new wheat to an area, the smaller farmers were just as likely to start sowing it as those cultivators with large holdings. He further shows that the pattern that farmers with the largest holdings were the first to sow dwarf wheat followed by the smaller farmers, did not exist (9). The size of the area farmed may be acting both directly and indirectly on the adoption rate of the new high yielding varieties. It is related to other statistically 'independent' variables such as caste and education level of the farmer (Fig.2.4), and so might well influence the dependent variable through one of these, or vice versa.

In Appendix 4, p.487, the close relationship between the size of the area farmed and caste was discussed. Caste groups I and II, the Jats, Brahmins, Rajputs, Gujars and Lodhas farmed significantly larger areas than the Chamars, the Muslims and the Muslim Rajputs, and as Fig.4.10 showed, the larger farmers were the earlier adopters of the new wheat. The results of the Kolmogorov-Smirnov test show that members of higher castes farm the larger areas in this sample. There was no significant difference between the distribution patterns of farm size in groups I and II, but these combined groups differed markedly from the form of the frequency curve of caste group III ($D = 71.9$, significant at the 0.1 per cent level of probability) (Fig.4.10). As the size of the area a farmer cultivates is unlikely to influence caste, and as these two 'independent' variables are so closely related, it appears that caste and the size of the area farmed

are both explaining much the same part of the variation in the dependent variable, that is, the pattern of the adoption rates of the new high yielding varieties. Caste is probably still the major influencing factor on the dependent variable, and the relationship between the size of the area farmed and the dependent variable is probably an indirect effect of caste on the adoption rate of the new high yielding varieties. The value of the variable 'size of the area farmed' in explaining the variation in adoption rates is much reduced due to its relationship with caste.

Table showing the rate of adoption of dwarf wheat by cultivators using different sources of irrigation water.

| Source of irrigation water | % adopters of total farmers. | No. of farmers | 1965 - 66 | 1966 - 67 | 1967 - 68 | 1968 - 69 | 1969 - 70 | 1970 - 71 | 1971 - 72 |
|----------------------------|------------------------------|----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 1 | 27.00 | 53 | 26.42 | 20.70 | 7.56 | 17.00 | 9.45 | 17.00 | 1.87 |
| 2 | 4.10 | 8 | 50.00 | 12.50 | | | 25.00 | 12.50 | |
| 3 | 10.20 | 20 | 25.00 | 15.00 | 20.00 | 5.00 | 10.00 | 20.00 | 10.00 |
| 4 | 3.50 | 7 | | | 42.90 | | 14.20 | 42.90 | |
| 5 | 13.30 | 26 | 23.12 | 19.21 | 46.24 | 7.70 | 1.86 | 1.86 | |
| 6 | 41.00 | 80 | 17.54 | 15.00 | 13.75 | 18.75 | 16.25 | 12.50 | 5.00 |
| 7 | 1.00 | 2 | | 50.00 | 50.00 | | | | |

Codes of sources of irrigation.

1. open well.
2. pond.
3. canal.
4. government tube well.
5. own tube well.
6. neighbour's tube well.
7. own pump set.

Source: Field work for the Wheat Study - March 1972.

Fig.4.11

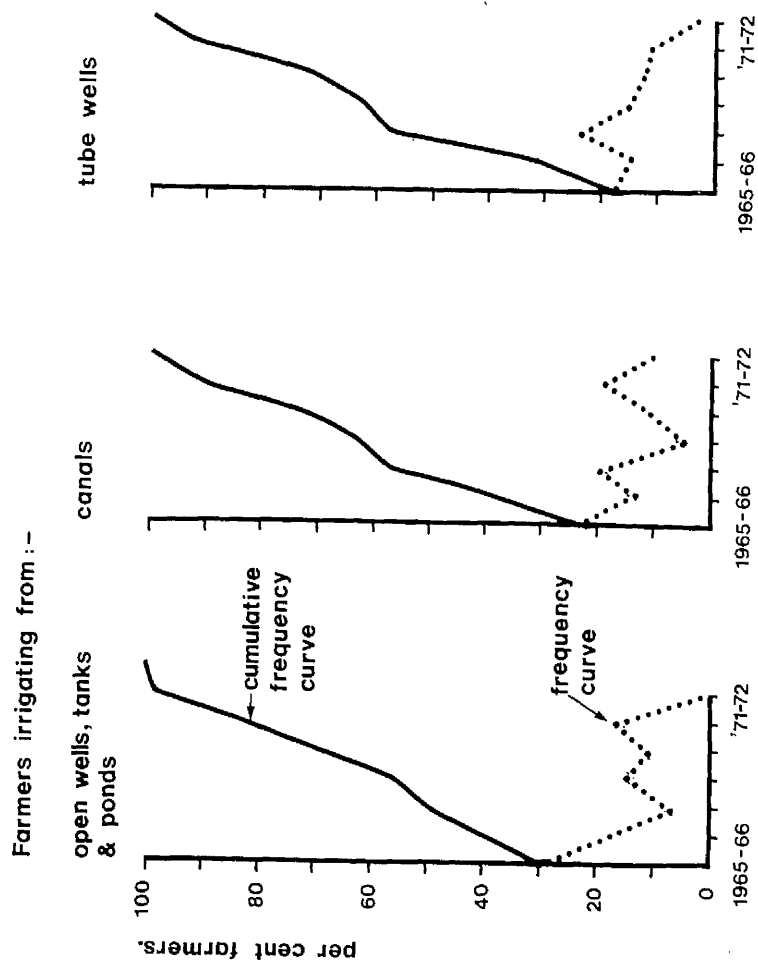
iv. The relationship between the availability of irrigation water and the rates of adoption of the new high yielding varieties of wheat.

A reliable source of irrigation water is perhaps the most important requirement of the high yielding wheat varieties. Bulandshahr was in a relatively favourable position when the new wheat was introduced to India, as 62.74 per cent of the cropped land was irrigated in 1965-66 (10), and 43.01 per cent of this area was watered by canals built in the nineteenth century. Those farmers who did not have access to a reliable source of irrigation water, such as canals, were immediately barred from the apparent advantages of the green revolution. This resulted in the development of tube wells as an alternative source of irrigation water. Since their widespread introduction in 1965-66, tube wells have come to be the dominant irrigation source in the district. (Fig.3.23).

The purpose of this section is to examine the rates of adoption of the high yielding varieties of wheat by farmers using different methods of irrigation. It is clear from Fig.4.11 that open wells, canals and private tube wells are the most common sources of irrigation water, and farmers using other methods are definitely in the minority in the study area.

Fig.4.11 shows the rate of adoption of new wheat each year since 1965-66. The greatest proportion of tube well users apparently adopted new wheat later than did farmers using canals and other more traditional sources of water. This could not be 'proved' statistically, and by 1968-69, the majority of farmers using each type of irrigation had adopted the new wheat. The farmers seemed

PERCENTAGE ADOPTION OF THE NEW WHEAT ACCORDING TO THE MAIN SOURCE OF IRRIGATION.



Source: Field work for the Wheat Study - March 1972.

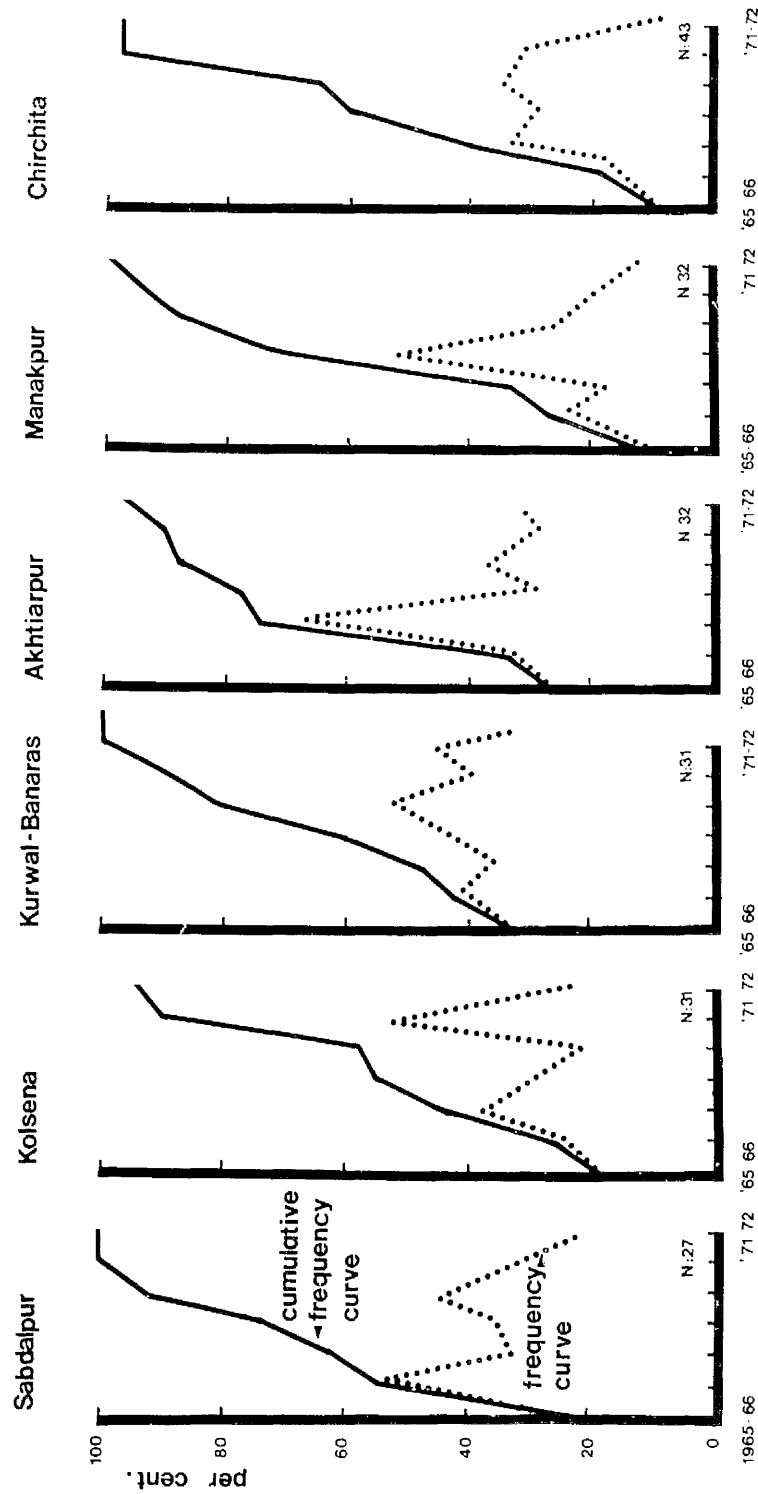
Fig.4.12

equally prepared to innovate regardless of their water source.

The data were then plotted to see if the adoption rates of cultivators using the various irrigation methods followed the model 'S' shaped curve (Fig.4.12). As the number of farmers using tanks and ponds, and government tube wells were so few, they were included with other major groups (Fig.4.12). The two cultivators using their own pumping sets were omitted from this section. In no case can the cumulative frequency curves of Fig.4.12, be said to approximate an 'S' shape and neither does the frequency distribution approximate to normality when examined with the chi square test.

It cannot be concluded from this section that cultivators using any particular source of irrigation have adopted the new varieties of wheat significantly earlier or later than other farmers. As a result of the Kolmogorov-Smirnov test, which showed that the curves were all significantly different, the null hypothesis claiming that the source of irrigation has no influence on the adoption rate of new wheat, cannot be rejected.

PERCENTAGE ADOPTION OF THE NEW HIGH YIELDING WHEAT VARIETIES IN EACH VILLAGE.



Source: Field work for the Wheat Study - March 1972.

Fig. 4.13

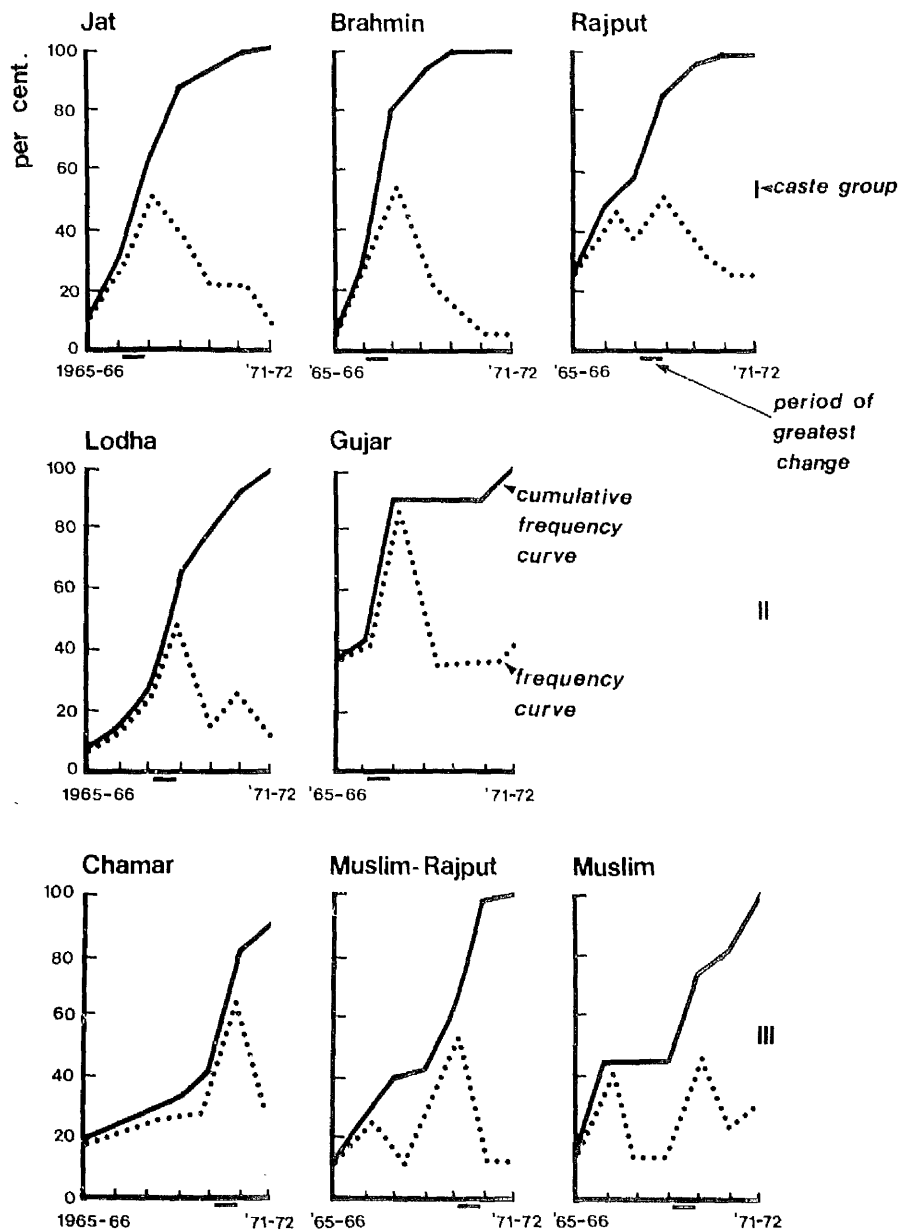
- v. The relationships between the village identity of the farmer and the rate of adoption of the new high yielding varieties of wheat.

The data were next divided at the village scale to examine patterns of adoption of the new high yielding varieties in the study area. The cumulative frequency curve of adoption was plotted, and from Fig.4.13 it is clear that the mean gradient of the curve for each of the six villages is far greater than for the entire sample of 196 farmers. In every village the approximation to an 'S' shaped curve is greater than the overall adoption rate indicates, (Fig.4.2), and the period during which the majority adopt the new wheat in each village is always much shorter. This is because farmers in a village community are more likely to function as a single group, than are the entire sample of farmers enumerated for the study, and hence adoption is likely to occur over a far shorter time period in a village than over the study area as a whole. The 'S' shaped curve however, is never quite clear in any of the adoption curves for each village, and according to the Kolmogorov-Smirnov test differ markedly between one settlement and the next.

Every curve is interrupted at least once by a period when the adoption rate is well above the mean. Fig.4.13 also shows the frequency of the adopters of new wheat in each village in each year, and in no case is the curve normal in its distribution. Every curve has at least two peaks showing that there was more than one phase of rapid adoption. This suggests the presence of more than one community in each village, a hypothesis which has been examined in detail in section 1, p.149. The problem in this section is to isolate the period when the majority of farmers adopted the new varieties. This period differs between one village and the

next as in some cases the period of majority adoption was earlier than others (Fig.4.13). In consequence, a combination of the curves for the six villages has resulted in a single curve of gentle gradient rather than a curve with a pronounced 'S' shape (Fig.4.2).

ADOPTION PATTERNS OF 'NEW' WHEAT BY EACH CASTE.



Source: Field work for the Wheat Study - March 1972.

Fig. 4.14

vi. The relationship between caste groups and the rates of adoption of the new high yielding varieties.

As none of the other variables seem to influence the pattern of the adoption rate curve other than indirectly via caste, the data were divided according to the caste of the farmer and were plotted on Fig.4.14 to see if any pattern, such as an 'S' shaped curve emerged from the adoption rates of the new high yielding varieties. These cumulative frequency curves (Fig.4.14) resembled the theoretical 'S' shape more closely than any of the innovation curves examined earlier in this chapter. The non-cumulative forms of these innovation curves (Fig.4.14), were all significantly different from the normal distribution according to the chi square test. A number of them, however, were unimodal, and so it was decided to examine the skew of these curves. The curves constructed for the Rajput, the Lodha, the Muslim-Rajput and Muslim farmers had more than one peak (Fig.4.14), but it was decided to test these curves also, except for the Muslim curve, which was a more pronounced bimodal distribution than any of the others. In a formula comparing the median and the mean of each distribution, an indication of the level of skewness of each curve was obtained¹. If the curve was positively skewed, that is, weighted to the left of the distribution, a negative value was obtained for the index of skewness. If however, the value was positive, the curve was negatively skewed. Fig.4.15 summarizes the results: these results confirm that the curves of caste groups I and II were negatively skewed, and so confirms that the cultivators innovated earlier than the members of caste group III, the innovation curves of which are skewed more towards the positive side.

1. The method of estimating skewness is fully discussed in Blalock, H.HM 1960, op.cit., p.74.

Table showing skewness in non-cumulative caste innovation curves.

| | | | |
|----------------|------------------------|-----------------|--------------------|
| Jat -5.2 | Brahmin - 7.7 | Rajput - 4.0 | Caste-group. I. |
| Lodha -7.3 | Gujar - 5.0 | | II. |
| Chamar +2.7 | Muslim-Rajput + 1.0 | Muslims * | III. |

* skew not estimated.

Source: Field work for the Wheat Study - March 1972.

Fig.4.15.

Fig.4.16 further confirms these results and illustrates that more than 50.0 per cent of the members of caste group I, the Jats, Brahmins and Rajputs, had started growing the new high yielding varieties by rabi 1967-68. The Gujaras and the Lodhas of caste group II were not so consistent in their approach. By 1966-67, well over half the Gujaras had sown new wheat while comparable proportions among the Lodhas were found as late as rabi 1968-69. Of caste group III, the majority of the Chamars had sown dwarf wheat by 1970-71, while the equivalent proportions of Muslim and Muslim-Rajput cultivators had sown it the previous rabi.

The relationship between the proportion of adopters and the caste level is predictable in the cases of caste groups I and III. Local informants predicted that the Jats were the superior farming caste of the area, the Rajputs were a close second and the Muslims and their associate castes were the poorer farmers. The District Gazetteer of 1903 also mentions the agricultural dominance of the Jats (11). The status of farmers who were members of caste group II was not always predictable. The Gujaras

of Akhtiarpur appeared to be more progressive in their outlook than was originally estimated. Although the rate of adoption was not predictable from caste groupings, there was an indication that the majority of caste group I farmers were early adopters, while members of the third caste group began to sow the new wheat much later.

The proportion of adopters of the new high yielding varieties of wheat in each caste group.

| Caste group | No./ group | 1965 - 66 | 1966 - 67 | 1967 - 68 | 1968 - 69 | 1969 - 70 | 1970 - 71 | 1971 - 72 | per cent | |
|----------------|---------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|-------------|--|
| I. | | | | | | | | | | |
| Jats | 17 | 11.76 | 35.30 | <u>64.70</u> | 88.23 | 94.11 | 100.00 | 100.00 | | |
| Brahmins | 14 | 7.14 | 28.57 | <u>78.57</u> | 92.86 | 100.00 | 100.00 | 100.00 | | |
| Rajputs | 45 | 27.91 | 48.83 | <u>58.13</u> | 88.37 | 96.68 | 100.00 | 100.00 | | |
| II. | | | | | | | | | | |
| Lodhas | 26 | 7.70 | 15.38 | 26.93 | 65.38 | 80.76 | 92.30 | 100.00 | | |
| Gujars | 22 | 38.09 | <u>61.91</u> | 90.47 | 90.47 | 90.47 | 90.47 | 100.00 | | |
| III. | | | | | | | | | | |
| Chamars | 22 | 21.05 | 26.31 | 31.57 | 36.84 | 47.36 | <u>89.47</u> | 100.00 | | |
| M.Rajputs | 32 | 12.90 | 25.80 | 32.25 | 41.93 | <u>61.29</u> | 96.77 | 100.00 | | |
| Muslims | 11 | 9.10 | 45.45 | 45.45 | 45.45 | <u>72.72</u> | 81.81 | 100.00 | | |

Source: Field work for the Wheat Study - March 1972.

Fig.4.16.

Where a single caste group does not dominate a village either in terms of numbers or in terms of 'power' resulting from 'high' caste or wealth, an 'S' shaped curve of adoption is not present. In the case of Sabdalpur, Chirchita and Kolsena (Fig.4.13), it appears as though the adoption rates of more than one group have been combined. Similarly, in the division by caste, the adoption curves of the Muslims and Muslim-Rajputs show more than

one section where the gradient is above average (Fig.4.14).

Members of these castes are to be found in at least two villages, and so they did not react to the innovation in the same way as other members of the same caste. These farmers probably followed the patterns of adoption in their individual villages more closely.

Three and four castes are present in Manakpur and Kurwal-Banaras, but the adoption rates in these villages do follow the pattern of the 'S' shaped curve (Fig.4.1). This suggests interaction between members of different castes, and in these instances the farmers seem to identify with a village group, rather than a caste group, and so the village community probably has the major influence on the decisions made by the farmer. During the field work in these villages one was not aware that more than one caste group was present. This situation contrasted strongly with Chirchita where the Jats and Muslim-Rajputs did not even communicate, and similarly, in Kolsena conditions were even more extreme where Lodhas and Chamars lived in separate, nucleated settlements.

The Lodhas of Manakpur, according to the assessments of the enumerators, were a fairly high jati¹ within their caste, while the Rajputs were probably of lower jati as they were prepared to mix with the Lodhas. According to Jat enumerators for the Wheat Study, the association of Lodhas with Rajputs was one means available to the former of 'moving up' the caste hierarchy. Where such strong links exist between members of different castes, the village unit appears to be strengthened as opposed to the caste unit.

1. Jati - social grouping within a caste.

The situation in Kurwal-Banaras is very similar to Manakpur, and once again Rajputs and Muslims appeared to associate freely. In both Manakpur and Kurwal-Banaras where the farmers tended to identify more with a village group rather than a caste group as they did in Chirchita, the patterns of change in the adoption rates of the new varieties seemed to be strongly influenced by the group which the farmers identified themselves with most readily.

The analysis so far has been conducted first, at the scale of the entire study area when all 196 sample farmers were considered together as a single group, and then at the level of the six 'independent' variables - the year of instruction in new farming techniques, education level, main source of irrigation water, farm size, village identity and caste. Far more information has emerged at these more detailed scales than when the sample was treated as a single unit. The results of the section on caste have suggested that investigation of this variable at an even more detailed level could provide further information relating to adoption rates of the new high yielding varieties of wheat. The next section therefore, is conducted at the more detailed scale of caste groups within each village.

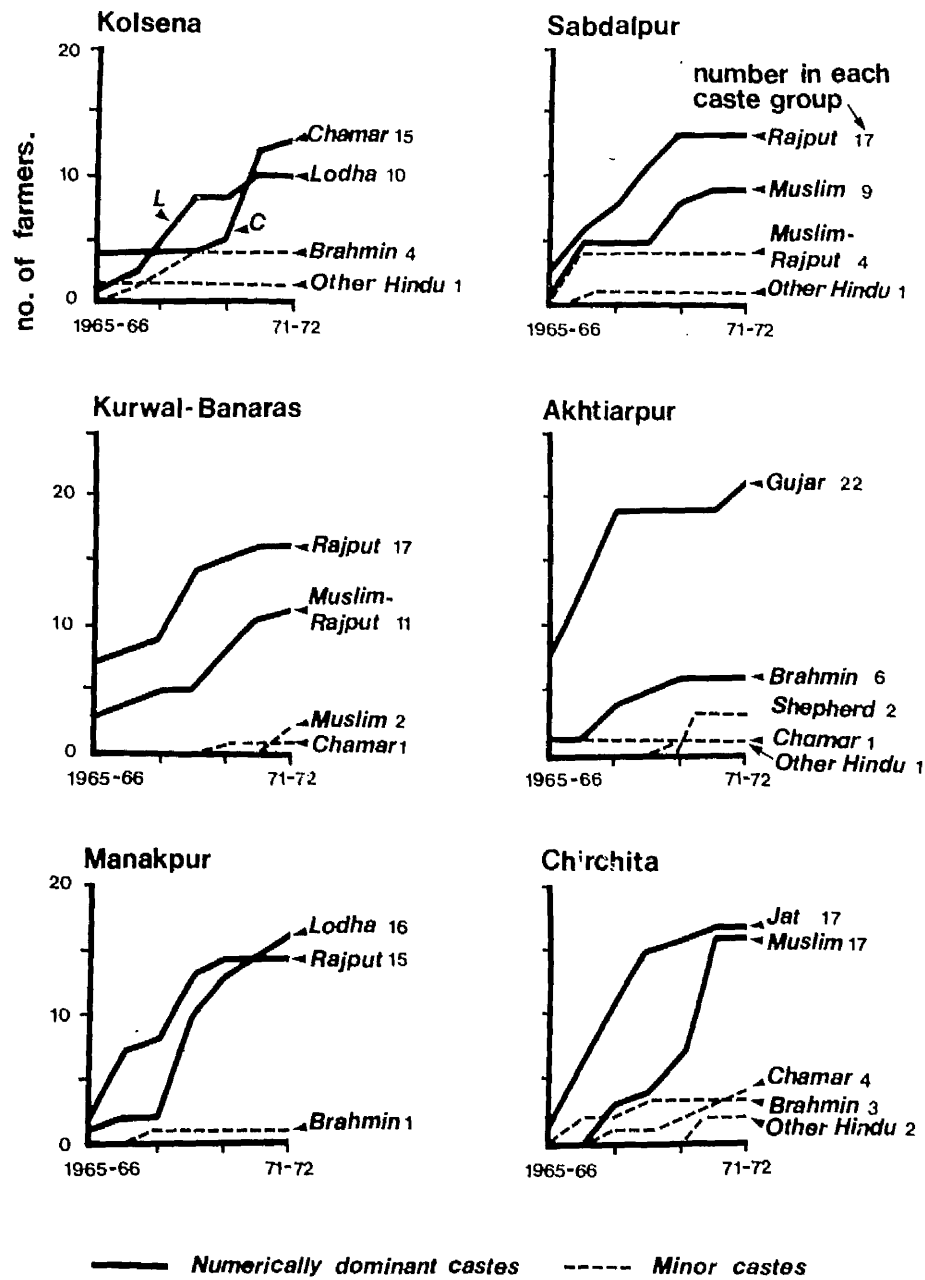
The relationship between caste groups in the villages and the rate of adoption of the new high yielding varieties of wheat.

Both directly and indirectly, caste appears to have the most significant influence on the rate of adoption of the new high yielding varieties of wheat. Claims are frequently made in India that the caste hierarchy no longer exists with the force it once did. It may not in certain societies, particularly in urban areas, but in rural areas much of the tradition remains and caste divisions are still in evidence (12).

It has been shown in the preceding section that it would not be possible to predict precisely from caste, with any level of confidence, that the adoption rate of the new high yielding varieties of wheat would follow a theoretical 'S' shaped curve. The pattern among the Rajputs and Muslims did not appear to be so simple (Fig.4.14). If field work impressions are true, affinities between groups of farmers are strong and they are all well aware of what their neighbours are doing; it is logical to suppose that the introduction of a successful technique by a few would lead to rapid adoption by the majority, and finally, the remaining few sceptics might experiment too. If the level of communication within a group was high, this should happen, if not, the adoption rate curve could be modified.

In retrospect, there is no reason to suppose that an information net exists between farmers who cultivate holdings of similar size, regardless of location. Nor is there any reason to suppose that farmers who either do or do not receive education, function as community groups. There were only two groups where

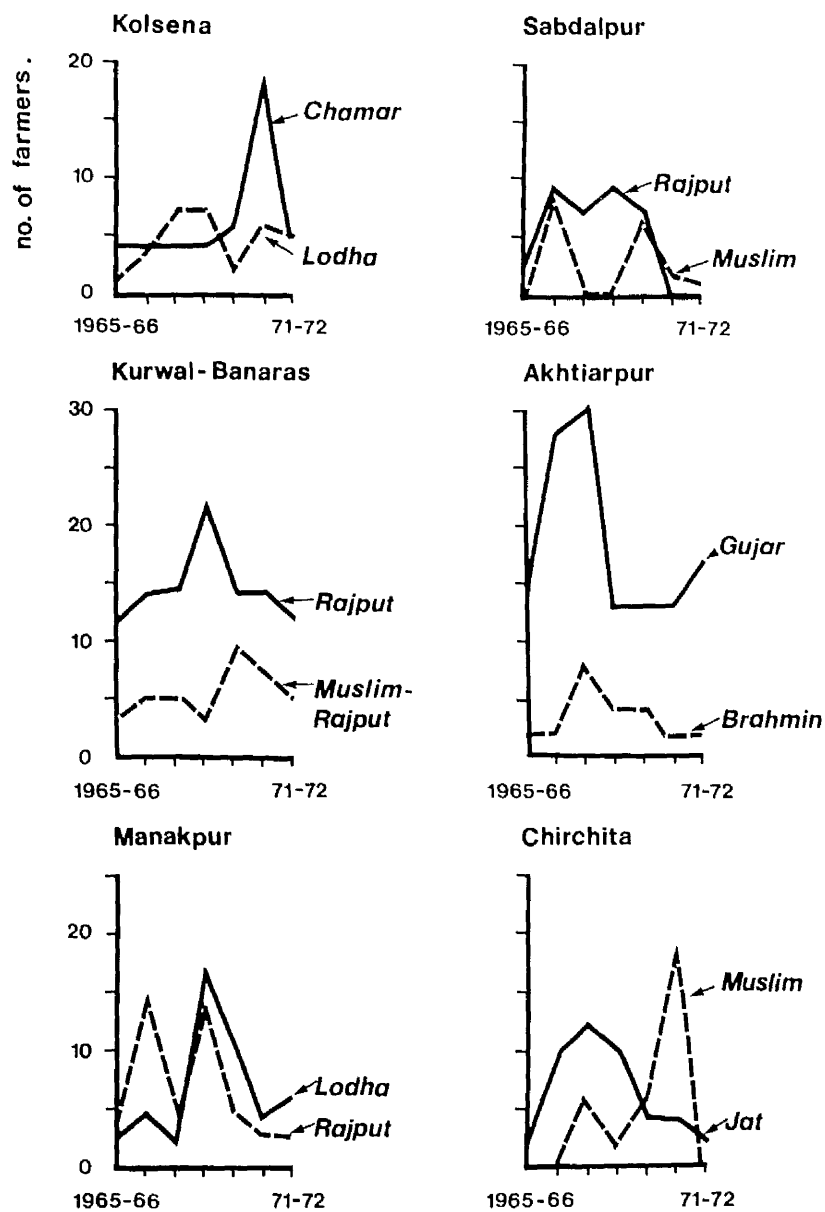
ADOPTION PATTERNS OF THE NEW WHEAT VARIETIES BY
EACH CASTE IN EACH VILLAGE.



Source: Field work for the Wheat Study - March 1972.

Fig. 4.17

ADOPTION PATTERNS OF THE NEW WHEAT VARIETIES BY
EACH CASTE IN EACH VILLAGE.
(frequency distributions)



Source: Field work for the Wheat Study - March 1972.

Fig. 4.18

close association between the member farmers seemed likely, the village groups and caste groups. However, we have shown that individually neither gave characteristic 'S' shaped curves for the new wheat adoption rates. When these were further reduced to the level of caste groups within the village, the shape of the 'S' shaped innovation curve does become clearer (Fig.4.17). Although the adoption rates of all the caste groups are plotted, it is only the major caste groups which are of significance, as the sample size of the minority groups is too small. Fig.4.17 shows the adoption rates of members of caste groups within the villages, and for the first time we can discern the 'S' shaped curve. Though the curves lack the initial period of gradual increase, all show a period when there was a rapid increase in the number of adopters, and this was followed by a decrease in the adoption rate.

However, when the frequency curves (i.e. non-cumulative) of the major castes were plotted (Fig.4.18), they still differed significantly from the normal distribution, and furthermore, when the two curves were compared for each village, the Kolmogorov-Smirnov test showed them to be significantly different in each case, so emphasizing the different rates of adoption by each caste. Fig. 4.18 shows quite clearly that the peak period of adoption of one caste group always occurred at a different time from the other major caste group of the village. In some of the villages, such as Manakpur there were two periods when the number of wheat growers increased rapidly. This was apparent both from the abrupt changes in the cumulative frequency diagram and in the bimodal frequency curves in Fig.4.18. These patterns can be explained by supplementary evidence gathered in the field. Certain Rajputs

were more influenced by the Lodhas of the village than by other members of their own caste, and so adopted the new varieties at the same time as the Lodhas. The other Rajputs began experimenting with the new varieties earlier. A similar situation occurred in Kolsena (Fig.4.18), where some of the Lodhas were closer to the Chamars than to the members of their own caste group. It was only in a few cases, such as the Gujars of Akhtiarpur and the Muslims and Jats of Chirchita, that there was one major peak to the frequency curve of adoption (Fig.4.18). These data confirm field observation that each of these three groups was more socially united than were the Lodhas and Rajputs of Manakpur, and so tended to adopt new farming techniques over a shorter period of time.

Where unimodal curves were present, however, they were never normal, the reason for this, invariably being their skewed distribution. It must be said that none of the innovation curves compared closely with the theoretical innovation model. Unfortunately, it was not possible to examine the skew of each unimodal curve, as the sample size of each caste in each village was too small. Although the adoption curves mostly displayed one period when the majority of the farmers of a single caste adopted the new varieties, the curves deviated quite markedly from the shape of the theoretical innovation curve, because one was 'cutting across' boundaries. Even within a village caste groups do not behave as a single unit, and so do not display the uniform patterns of adoption demanded by the theoretical model.

Where a single caste dominated in terms of numbers, even if they were not the 'highest' caste according to Hindu convention,

Table to show the proportion of farmers of each caste in each sample village.

| <u>Village</u> | <u>Caste groupings.</u> | | | | Total nos. |
|----------------|--------------------------------|--------------------------|--------------------------------------|-----------------------------|------------|
| | I <u>Jat Brahmin Rajput</u> | II <u>Lodha Gujar</u> | III <u>Chamar Muslim M.Rajput</u> | IV <u>Hindu Shepherd</u> | |
| Kolsena | 12.90 | <u>25.48</u> | <u>45.16</u> | 3.23 | 31 |
| Sabdulpur | <u>48.14</u> | | <u>33.33</u> 4.82 | 3.70 | 27 |
| Kurwal-Banaras | <u>54.84</u> | | 3.23 6.45 | | 31 |
| Akhtiarpur | 18.75 | <u>65.65</u> | 6.21 | 3.13 | 32 |
| Manakpur | 3.13 | <u>43.75</u> | <u>50.00</u> | 3.13 | 32 |
| Chirchita | <u>39.54</u> | | 9.30 <u>37.21</u> | 4.65 | 43 |

Source: Field work for the Wheat Study - March 1972.

Fig.4.19

they set the trends for the village and were usually responsible for the introduction of dwarf wheat (Fig.4.19). In Akhtiarpur, for example, over 65 per cent of the farmers were Gujars, members of caste group II, and when we were in the village, they seemed to occupy a prominent position, despite the presence of a smaller Brahmin element (Fig.4.17). The fact that the latter rank more highly in Hindu society seemed of little significance in Akhtiarpur where the Brahmins held a fairly important position, and of even less significance in Manakpur, where the Brahmins were a poor minority and much less enterprising than the Rajputs. According to Hunter (1969),

"Brahmins may be poor and relatively uninfluential in a village dominated by a powerful landed group of 'lower' caste..... What matters in secular village influence is the local ranking and predominance achieved by a particular group." (13)

Where more than one caste was present in a village and none dominated in terms of numbers, such as in Kolsena and Kurwal-Banaras, the members of the 'higher' caste always emerged as the dominant group, and the innovators, even if they were surpassed in time. In Kurwal-Banaras for instance, the majority of the Rajputs adopted the new wheat between 1967-68 and 1968-69, while the Muslims started sowing dwarf varieties the following year. Similarly the Gujars who accounted for over 65 per cent of the Akhtiarpur sample showed a great increase in the number of adopters between 1965-66 and 1967-68. The Brahmins who were in the minority in Akhtiarpur tended to follow the Gujars, while the Chamars were even slower to adopt the new seed. In Manakpur, the Rajputs of caste group I showed their initial rise in the proportion of new wheat growers between 1965-66 and 1966-67.

A secondary Rajput element showed an increase in the number of dwarf wheat growers between 1967-68 and 1968-69, two seasons later. A similar pattern is present in Kolsena with the Lodhas and Chamars.

Village Chirchita on the other hand, was an example of a village where there is little interaction between the major caste groups. 16 of the 17 Jats had started to grow new wheat by 1968-69, whereas by this stage only 25 per cent of the Muslim-Rajputs had adopted new wheat. The two minority groups of Brahmins and Muslims seemed to follow the pattern of the Jats and Muslim-Rajputs respectively. From Fig.4.17 it is apparent that these curves of adoption rates are far from coincident as they sometimes appear to be in the other villages.

The minority groups tended to adopt the new high yielding varieties later as a rule. In Kolsena, however, the six Brahmins were in the minority, but they were the innovators in the village. Most of these Brahmins farmed over 32 bighas (2.59 hectares) and their farms were often about 100 bighas (8.10 hectares). Though they were not in the majority, the Brahmins were of high caste and the former analysis showed that larger farmers were frequently the first to innovate. Prediction of the patterns of adoption rates is difficult for the minority groups, but on the whole the strongest caste either in terms of numbers or status, dictates the trends. Lipton (1973) (14) describes this as 'castecracy' in his study of dominant castes in villages, and to give further support to the results of the Wheat Study, the data of the District Study (1972) have shown that within the villages the separate caste

groups react in different ways to the new farming techniques.

From this section which analyses the material at its most detailed scale, an ordering has emerged in the patterns of adoption of the new high yielding varieties of wheat. Farmers who were of 'higher' caste, cultivated the larger farms and were influential in their particular community and were very often the innovators. By 1971-72, the innovation was almost complete in the study area as the new high yielding varieties of wheat had been adopted by 97 per cent of the sample. This increase in popularity of the new varieties led to a change in the importance of deshi wheat, and the nature of this change is discussed fully in the following section.

4.3. The decline in the number of farmers sowing indigenous varieties of wheat.

The authors of all the studies cited which have examined the increase in the adoption of the new high yielding varieties, have neglected to make any comment on their influence on the indigenous varieties. No comparative material is available at all in this field, other than that collected by the District Study (1972). Unfortunately, this does not examine the temporal change in deshi wheat farming, but is solely concerned with the spatial distribution of the indigenous wheat in rabi 1971-72.

Data relating to deshi wheat in this study are based entirely on questionnaire material, and so on the memories of the cultivators. As they have been sowing the indigenous varieties since they began farming, the farmers found it much more of a problem to remember the area sown to deshi for more than three previous rabi seasons. Consequently, the time span over which patterns of deshi wheat farming are examined is shorter than that considered for the new high yielding varieties. This was unfortunate but unavoidable.

While the new high yielding varieties have been gaining popularity, the area sown to deshi wheat has declined. Fig.4.20 illustrates the change in the number of deshi growers over the three rabi seasons prior to 1971-72.

Table to show the change in the proportion and number of farmers sowing deshi wheat.

| | <u>1969-70</u> | <u>1970-71</u> | <u>1971-72.</u> |
|-----------------------------------|----------------|----------------|-----------------|
| Per cent | 58.16 | 43.87 | 28.58 |
| Number of <u>deshi</u> growers | 114 | 86 | 56 |

Source: Field work for the Wheat Study - March 1972.

It might be expected that the decline in deshi wheat would reflect a reverse 'S' shaped curve. Unfortunately no material was available which could indicate the rate of decline in deshi between 1965-66 and 1968-69. The proportion of deshi growers between 1969-70 and 1971-72 appeared to be consistent at village level (Fig.4.21), and the chi square test for 'K' samples (15) confirmed this observation. The decline in popularity in the indigenous variety could not be related to the variable 'caste groups within the villages', which had been of importance earlier in the chapter (p.177) as the number of deshi growers in each group was too few to provide any reliable conclusions.

Table to show the changing number of deshi wheat growers at village level.

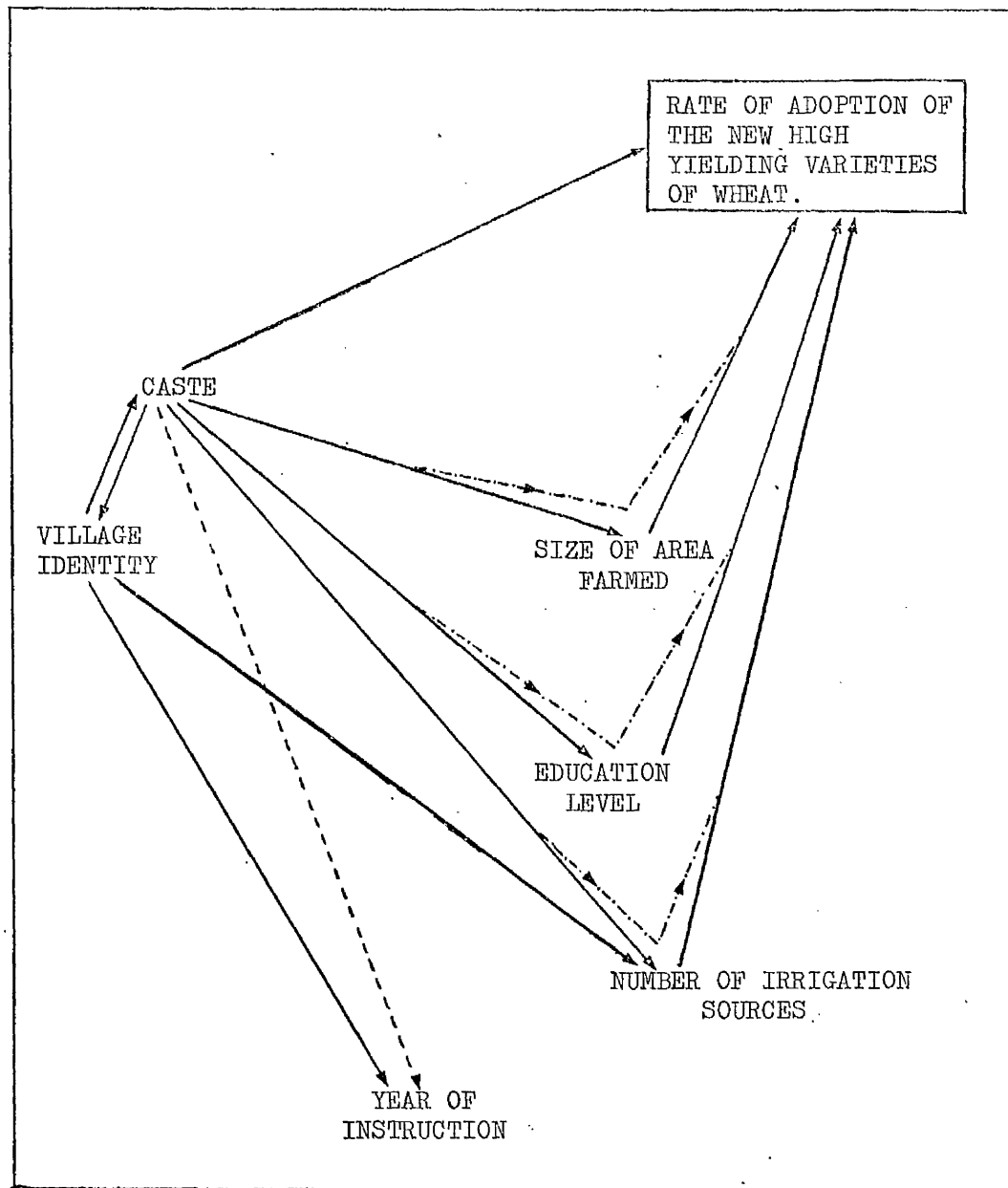
| <u>Village</u> | <u>Rabi</u> | | | |
|----------------|----------------|----------------|-----------------|--------------------------------------|
| | <u>1969-70</u> | <u>1970-71</u> | <u>1971-72.</u> | |
| Kolsena | 61.29 | 45.16 | 29.03 | per cent <u>deshi</u> growers. |
| Sabdalpur | 25.93 | 25.93 | 18.52 | |
| Kurwal-Banaras | 74.12 | 67.74 | 48.39 | |
| Akhtiarpur | 59.38 | 56.25 | 34.38 | |
| Manakpur | 65.63 | 40.63 | 28.13 | |
| Chirchita | 18.61 | 30.23 | 18.61 | |

Source: Field work for the Wheat Study - March 1972.

Fig.4.21.

Farmers appear to treat deshi merely as 'another variety' and it is usually grown in small quantities for home consumption. It would be a genetic tragedy if farmers continued to reduce their deshi wheat any further, as the indigenous varieties provide a

Diagram summarizing the direct and indirect factors which influence farmers to grow new dwarf wheat



- > Statistically significant relationships.
 (minimum level of significance = 95 per cent).
 - - - - -> Possible causal relationships not statistically significant.
 - . - . -> Possible indirect relationships

Source: Field work for the Wheat Study - March 1972.

Fig.4.22

wide gene pool from which the high yielding varieties are bred. It is however, more profitable for the farmer to grow the higher yielding dwarf wheat even though the input requirements are so high. Since the introduction of the Mexican dwarf varieties, farmers have been increasing their total area sown to wheat at the expense of other rabi crops, such as barley and gram (Fig.3.18), and have also been replacing their deshi wheat with the new high yielding varieties.

In the preceding analysis we have attempted to assemble evidence to test the null hypotheses, that there has been no significant change in wheat farming patterns within the study area (Chapter 2.p.59). By showing that caste and farm size are helpful in explaining the marked changes which have taken place in the study area with the adoption of high yielding varieties in preference to deshi wheat, the claims of the null hypothesis can be rejected. The possible causes of change have been fully considered and are summarized in Fig.4.22. The former shows relationships which have emerged from the analysis and the variables which appear to have both a direct and an indirect effect on the rates of adoption of the new wheat in the Wheat Study area.

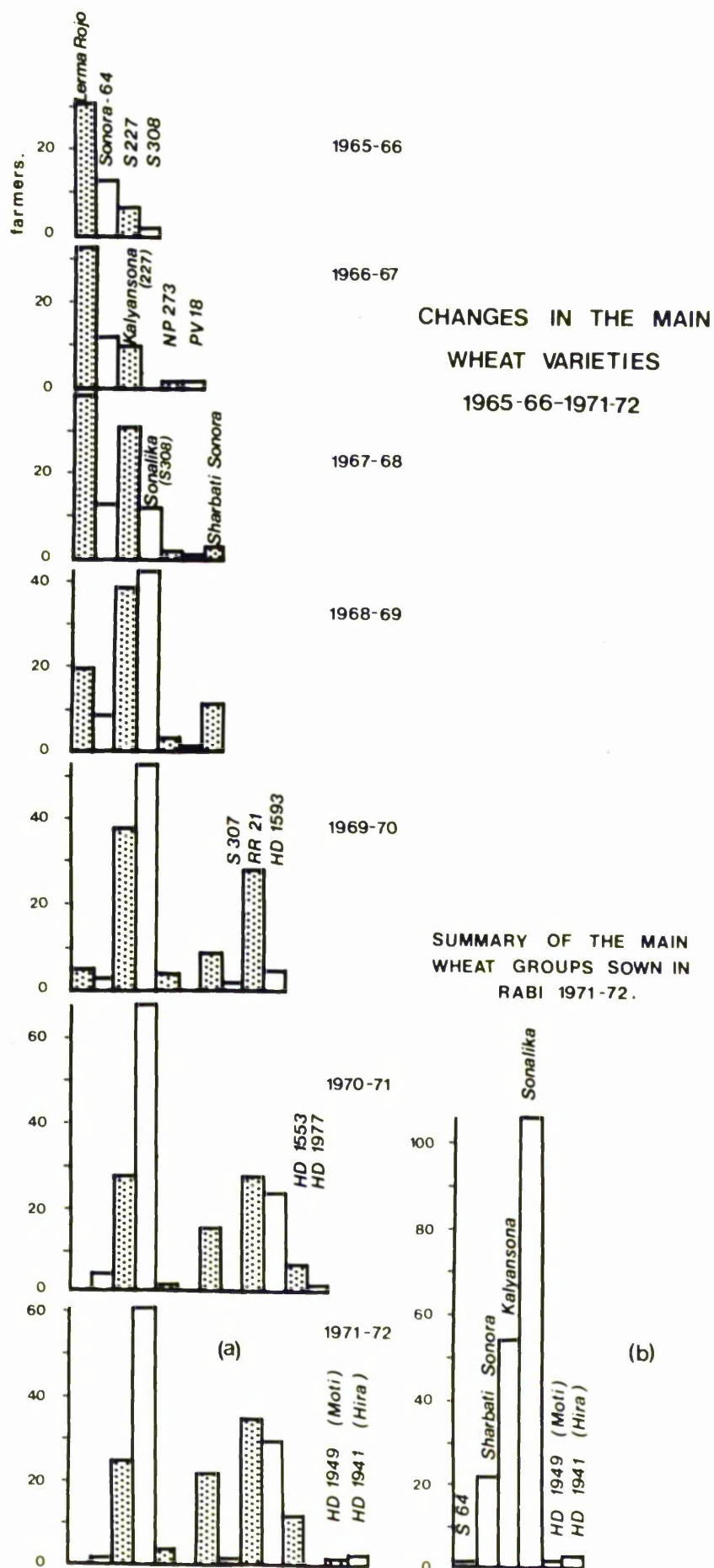


Fig. 4.23

4.4. Changes in the main varieties of wheat which have been sown by the farmers since 1965-66.

As the adoption rate of dwarf wheat has increased, so have the varieties available to the cultivator. Varieties popular in 1965-66 are no longer so widely grown in the study area and have been replaced with wheat of greater yield potential. In this section, changes in the main varieties grown since the adoption of new wheat will be examined. Each of the 196 farmers was asked in which year he adopted the new high yielding varieties, and which was his main variety in each successive rabi season. New wheat included all those varieties which had been imported from Mexico, or were Mexican Indian hybrids. Indigenous improved varieties have been introduced to the farming scene constantly since the later part of the nineteenth and early twentieth century (16), but in order to avoid confusion, these were omitted in this instance. Lerma Rojo and Sonora 64 were among the first red wheats introduced into India from Mexico (17), and despite much criticism, Fig. 4.23 shows that a relatively large number of the farmers were prepared to sow the new wheat because of their higher yields.

The Mexican varieties have been crossed with selected indigenous varieties, and certain amber grained wheats resulted - S227, S308, S307, S331, which underwent extensive trials during 1965-66 before their official release to the farmers. These varieties had the dwarf characteristics, together with the amber coloured grain. They had the additional advantage of superior yielding abilities than did the existing Mexican red wheats, Lerma Raja and Sonora 64, and also were fairly resistant to local pests (18). Continual breeding programmes are carried out at the major agricultural colleges and universities within each state, so that strains

adapted to local characteristics can be developed.

Fig.4.23 illustrates the change in use of the new high yielding varieties for the entire 196 farmers since 1965-66.

A further word of explanation about this diagram (Fig.4.23) is necessary, as it shows a considerable amount of information.

Contrary to convention, the time axis of the diagram moves in a vertical as opposed to a horizontal direction, so that the rise and decline in importance of any single variety can easily be traced from 1965-66 to 1971-72. By positioning the time axis in a vertical direction, the gradual increase in the number of available varieties is also apparent, as the entire width of the histogram increases from year to year. As many of the varieties are genetically similar and cannot be distinguished in the field, the histogram for 1971-72 has been summarized in Fig.4.23b. to show the importance of the major wheat groups within the study area. Reading Fig.4.23 from top to bottom, Lerma Rojo was the outstanding favourite in both rabi 1965-66 and 1966-67, and Sonora-64 came next, but far behind in terms of the number who grew it as the main variety. Both the red wheats reached their peak in rabi 1967-68, but already Lerma Rojo had been surpassed by S227 which two farmers had started to sow as early as rabi 1966. Dates of release and innovation are difficult to compare because the enthusiasm of farmers to obtain the 'newest variety', has led to a growing black market in new wheat seed which often has not been officially released for sale. In this situation it is possible that farmers sowing varieties of wheat before their official release dates are not providing wrong information, but, through fair means or foul, have been able to procure a certain amount of seed for themselves very

close to the time when the seed was released. The actual release date of S227 was not available, so whether the seed was sown prior to its official release date or not cannot be estimated.

By 1968-69, variety number S308, officially released in rabi 1966-67 had become the variety used by 49 per cent of the adopters (Fig.4.23). Four times the number of farmers sowed it as their main variety as in the previous rabi. S227 from which had been bred Kalyan 227 was affected by rust (19), but in rabi 1968-69 it reached its peak. 37 per cent of the adopters were sowing it as their main variety. Together, these were by far the most popular varieties among the farmers. Lerma Rojo occupied third position, but Sharbati Sonora, a hybrid of Sonora-64, was being increasingly used. Sharbati means amber, and after a slight decrease in 1969-70, the number of farmers who sowed Sharbati Sonora continued to increase, though far from dramatically. According to the recommendations of the Indian Agricultural Research Institute in Delhi (20) Sharbati Sonora was not a suitable variety for the plains of Uttar Pradesh.

By rabi 1969-70, the original Mexican varieties were used far less, and still S308 under the group name of Sonalika was the most important variety. 44.00 per cent of the farmers were sowing it as their main variety. Next in importance was Kalyansona, with Kalyan 227 being sown by 30.00 per cent of the adopters. The proportion of the adopters sowing these varieties has fallen slightly, owing to an overall increase in the number of farmers sowing new wheat (Fig.4.23) and to the fact that three new varieties had risen in status to being the main varieties of 35 farmers. One of these was variety RR21, which was originally released in

rabi 1966-67. Genetically it is very close to S308. When the breeding of S308 from the original Mexican variety number 308 began at the Indian Agricultural Research Institute, Delhi, a certain amount of number 308 was taken to Pantnagar University in Uttar Pradesh, where it was developed separately and released in 1966-67 as RR21. The two varieties are identical in the field except for the fact that a high proportion of RR21 shatters on maturing. It is felt that Fig.4.23 may be misleading in that the proportion of RR21 to its relative S308 may not be known. Except genetically, they are identical and can only be classed as Sonalika when examined in the field.

In 1969-70 Sonalika was the main variety of 64 per cent of the 120 adopting farmers. By 1971-72, Fig.4.23 shows that the pattern had changed little. Sonalika consisting of S308 and RR21 was the most popular type of wheat. Variety HD1553 was in evidence by 1970-71. This is another hybrid of the Sonalika group which has been developed at the Indian Agricultural Research Institute, Delhi, (HD = hybrid Delhi), and is resistant to shattering. In 1971-72, 54 per cent of the 193 adopting farmers grew it. Although the proportion has not changed significantly since 1968-69, the number of adopters of the new wheat has, and so Sonalika has increased in popularity. Variety HD 1593, a rust resistant version of Kalyan 227 was released in 1968. HD 1593 increased in importance quite markedly and this, together with S227 and Kalyan 227 constituted Kalyansona. Again, as with the Sonalika group, the individual members of Kalyansona are indistinguishable. In 1971-72, 27.00 per cent of the farmers were sowing the various members of the Kalyanasona group.

The farmers are advised to change their wheat every three or four seasons, but as they are unable to distinguish the individual members of the wheat groups in the field, the strains of wheat are not kept pure at harvest time. There seemed no point in examining the rates of adoption of the individual members, but their importance in terms of groups was felt to be relevant to the study. It must be said that, although distinction between one variety and another is not always possible, the farmers are at least well aware of the range of varieties in existence.

Both Sonalika and Kalyansona are highly recommended for the plains and Uttar Pradesh. Kalyansona is the early variety and Sonalika is suitable for both early and late seeding. Sonora-64 and Sharbati Sonora are not recommended for Uttar Pradesh as either early or late wheat. It was the main variety of only 22 farmers, by rabi 1971-72, and so it was not of great significance in the Wheat Study area. The farmers were aware of its unsuitability to the plains of Uttar Pradesh.

In 1970-71, there became available one of two new triple gene varieties, HD 1977 which was officially released in rabi 1971-72. The triple gene varieties have even higher yield potentials and their rise is just becoming detectable through the two farmers sowing HD 1941 Hira, and a third growing HD 1944 in rabi 1971-72. These varieties were released in 1970-71 and 1971-72 respectively.

An initial hypothesis was to examine the relationship between the dates of release and adoption. It was thought that

Table to show the number of main varieties used for the first time by each caste in each village.

| | <u>Number in each caste</u> | <u>Number of main varieties used for the first time.</u> |
|------------------------|---------------------------------|--|
| <u>KOLSENA.</u> | | |
| Chamars | 18 | 5 |
| Lodhas | 10 | 4 |
| Brahmins | 5 | 1 |
| Other Hindus | 1 | - |
| Shepherds | - | - |
| <u>SABDALPUR.</u> | | |
| Rajputs | 13 | 7 |
| Muslims | 9 | 1 |
| Muslim-Rajputs | 4 | - |
| | 1 | - |
| <u>KURWAL-BANARAS.</u> | | |
| Rajputs | 16 | 8 |
| Muslim-Rajputs | 11 | 6 |
| Muslims | 2 | - |
| Chamars | 1 | - |
| <u>AKHTIARPUR.</u> | | |
| Gujars | 22 | 6 |
| Brahmins | 6 | 1 |
| Muslims | 1 | - |
| | 1 | - |
| <u>MANAKPUR.</u> | | |
| Lodhas | 16 | 1 |
| Rajputs | 14 | 7 |
| Brahmins | 1 | - |
| <u>CHIRCHITA.</u> | | |
| Jats | 17 | 4 |
| Muslim-Rajputs | 16 | 1 |
| Chamars | 4 | - |
| Brahmins | 3 | - |
| | 2 | - |

Source: Field work for the Wheat Study - March 1972.

Fig.4.24.

the space of time between the release and adoption dates would decrease as the new wheat became more popular. This has not been the case because the new varieties are in extremely short supply and sufficient seed cannot be developed to comply with demands in under two to three years. Sonalika and Kalyansona occupy 83.00 per cent of the land sown with the main new varieties of wheat in the study area and the District Study (1972), confirms that these varieties predominate in Bulandshahr district. There was no evidence in the data to show that the pattern of the varieties being grown varied from one village to the next, or from one caste to another. Doubtless such a pattern would become apparent at district or even state level, but conditions for growing the new varieties are relatively constant throughout the district, where the soils, topography and climate show little variation, and such differences within the Wheat Study area are quite insignificant.

The only interesting pattern revealed by the analysis of the field data at village and caste level involved the number of varieties of wheat which had been grown in each village since 1965-66. The three canal villages of Sabdalpur, Kolsena and Kurwal-Banaras (Fig.1.4) showed most diversity in the varieties they grew (Fig.4.24), but in every village and in every caste, Sonalika was the most commonly sown variety by 1972, and Kalyansona, the second.

The data were examined to see which farmers were first to sow a new wheat variety as their main variety. This could point towards the innovating farmers of the study area, but it was not

necessarily the farmer introducing a strain to the area, who should be the first to sow it as his main variety. It could be the case, but personal preferences are involved and so, assumptions that the first farmer to sow his largest fields with a new variety was the innovator, could not be made. A pattern did emerge at the level of the caste groups in the villages, however, (Fig.4.24) and it appeared that in all cases except Manakpur, the dominant caste in terms of numbers was the first to sow a particular variety as their main variety. Although the Lodhas of caste group II were dominant in terms of numbers in Manakpur, during the enumeration, one was aware that the Rajputs were the more influential group in the village. The results that the Rajputs were the innovators therefore confirmed field observations.

Despite the fact that fourteen hybrids of Mexican wheat have at some time been grown by the farmers involved in the Wheat Study, relatively few varieties are very popular at present. This marked concentration on the Sonalika and Kalyansona varieties of wheat seems to be a feature of the whole of Bulandshahr district according to the District Study of 1972.

According to Kohli (1968) of the Indian Agricultural Research Institute, Delhi (21), Sonalika is preferred by the farmers because the wheat is amber, hard and resembles 'good quality Indian wheats' (22). When sown in 'rich' soil with adequate irrigation facilities, 'the wheat possesses a high degree of resistance to all three rusts and loose smut' (23). Sonalika also gives very high yields of superior quality grain

and chaff (24), the latter being of great value as animal fodder, and so the semi-dwarf nature of Sonalika makes it much more popular with the farmers than shorter varieties, which may be able to produce more wheat but whose additional yields of fodder are limited by their size. Strains of wheat 30 cm. tall have been developed at the Indian Agricultural Research Institute, Delhi, and this includes a 10 to 15 cm. head of grain. These varieties could not become popular with the farmers yet, because of the premium placed on a good yield of straw.

Kalyansona wheat, according to Kohli (25), possesses a very high resistance to three species of rust and loose smut. Mr V.S. Mathur, the chief wheat breeder at the Indian Agricultural Research Institute, Delhi claims that the opposite is true, and until the recent development of HD 1593, Kalyansona has been severely affected by these blights. If the plant is not badly diseased, the grain quality of Kalyansona is extremely good and yields are high. Both Sonalika and Kalyansona were widely grown in the study area, but their popularity might have been due to the limited choice of seed available to the cultivator.

Several seed varieties have been introduced to the area (Fig.4.23), but only certain varieties were well suited to the study area and have been developed, for instance Kalyansona and Sonalika, at the time of the Wheat Study. At first, seed was increased through the government organisations, such as the National Seeds Corporation, and then by local farmers themselves, so that these seeds were the most easily available new varieties in the district, and dominated the wheat sown area. The newest

triple gene varieties, Hira and Moti - HD 1941 and HD 1944, were in very short supply in rabi 1971-72, and since their release to farmers between 1970 and 1972, insufficient seed had been developed by the field work period for all the farmers to have access to these potentially higher yielding varieties; consequently, they had little choice but to sow the seed most readily available. If the relatively new triple gene varieties are a success in the area, extension work will concentrate on spreading these varieties and gradually Sonalika and Kalyansona will be replaced. A repeat of the pattern of the growing popularity and decline of Lerma Rojo and to a lesser extent the Sonora wheats (Fig.4.23), can be visualised.

The triple gene varieties are even more demanding on the farmer for their physical requirements than were the older single gene varieties, and the change from these varieties to the triple gene strains has been gradual; a necessary process, as the farmers are now learning the differences between the new wheat and the deshi varieties. Fig.4.23(a) might show a large selection of varieties available to the farmer, but many of these are almost identical genetically and Fig.4.23 (b) shows the varieties in their major groups. The number of varieties that has been released and developed in the area is severely restricted. One gets the impression that there are numerous high yielding varieties available because of the new strains which are constantly being introduced to the farmer. On the contrary, most of the wheat area is sown with relatively few varieties (Fig.4.23(b)) and the availability of a limited range, and hence, the relatively gradual change in the pattern of use of different wheat varieties in the study area is apparent from Fig.4.23.

4.5. Conclusion.

The results of this chapter on innovation patterns coupled with discussions with district agricultural officials indicated that new wheat seed had been in short supply, particularly in the years immediately after 1965. This has probably led to a modification of the theoretical adoption rate curve in the study area, particularly in its early stages. The theoretical 'S' shaped innovation curve is the result of a situation where a psychological constraint is the major influence on the decision to innovate. This situation does not compare with the Wheat Study area where supply constraints have largely been responsible for the adoption patterns of new wheat and of individual wheat varieties. Whatever the shape of the innovation curve, the null hypothesis that no significant changes have taken place in wheat farming patterns, cannot be accepted, as by 1971-72, within seven years of their introduction, 97 per cent of the farmers enumerated for the Wheat Study were sowing the new wheat varieties. These data, from a progressive farming area present results which green revolution enthusiasts want to see. The farmers are keen to experiment with the new varieties, and as they become more popular, the Indian government expects that crop production will increase as the yield potential of these new high yielding varieties is so much higher than the indigenous strains. If, in addition, the farmers increase the areas sown with these high yielding varieties, the subject to be discussed in the first part of the next chapter, a major change could take place in the scale of food production.

CHAPTER 5.

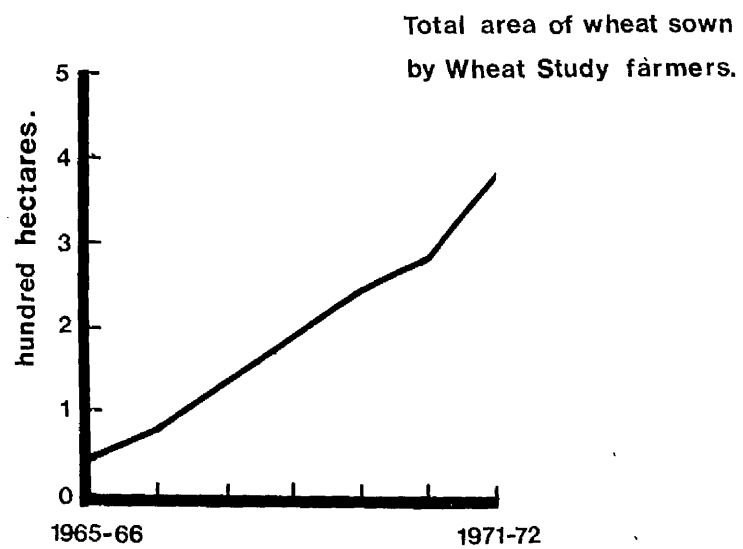
The changing areal pattern of high yielding varieties of wheat in the study area.

5.1. Changes in the areal extent of new high yielding varieties of wheat.

The High Yielding Varieties Programme was instituted in 1966 to raise the agricultural output in India. This was to be achieved by increasing the total area sown with the new varieties and, simultaneously increasing the output per unit area by the introduction of multiple cropping systems to which the new varieties are in theory well suited. In chapter 4 we saw that almost 100 per cent of the farmers adopted the new wheat within seven years of its introduction to the study area. This situation where the farmers are responsive to innovation, is an important factor in the success of the Programme. Chapter 5 first examines the changes in area sown to new wheat, and then considers the effect that the new varieties have had on the overall cropping patterns used in the study villages. In these two chapters, 4 and 5, we shall see how far the aims of the High Yielding Varieties Programme are being realised in the Wheat Study area.

In the first part of the chapter which discusses the change in area sown to new wheat, the analysis will be carried out at district level and also at the more detailed scale of the Wheat Study. The farmers were asked what area of new dwarf or indigenous improved wheat they had sown since they adopted these varieties. They found little difficulty in remembering this as the dwarf wheat still seemed very new to the farmer who is unaccustomed to such innovations.

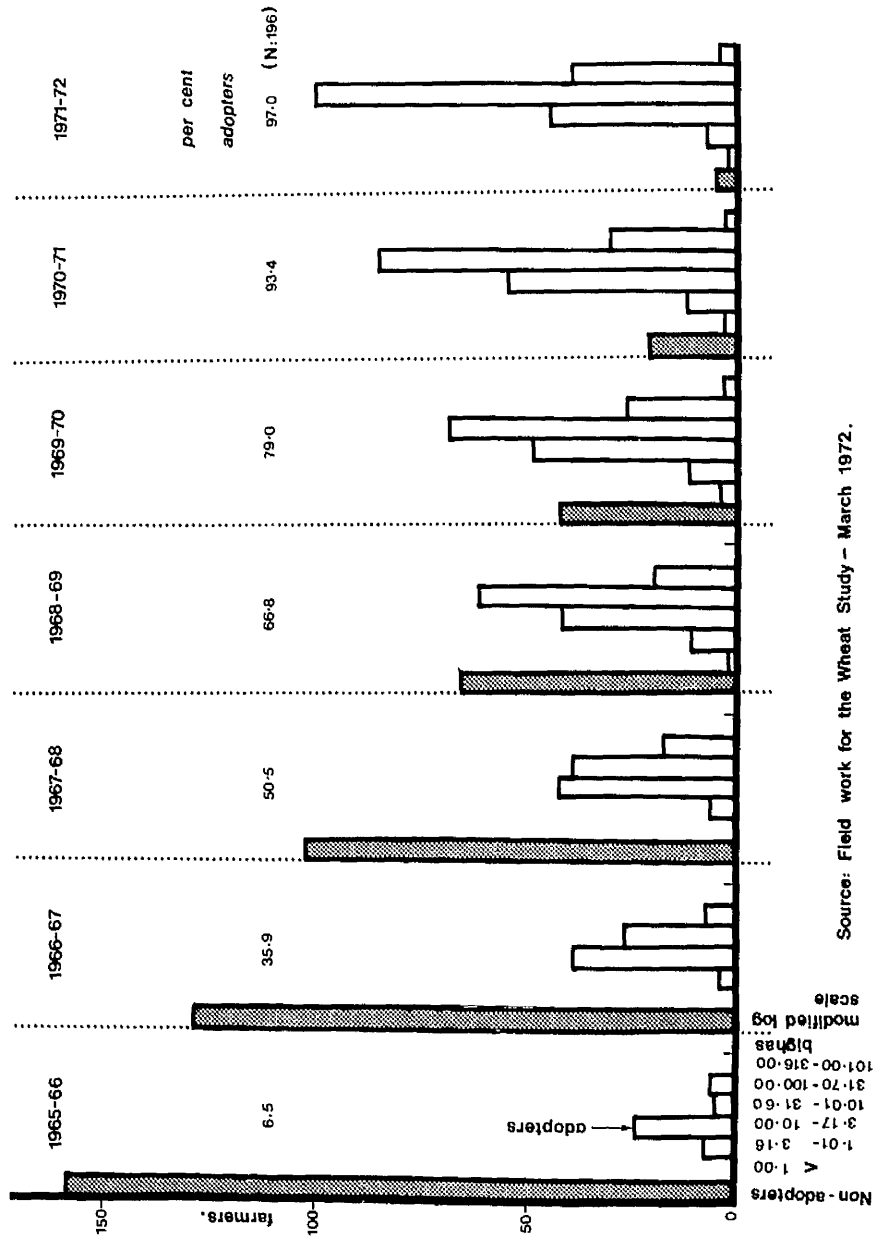
INCREASE IN THE AREA SOWN TO
DWARF WHEAT IN THE STUDY AREA.



Source: Field work for the Wheat Study-March 1972.

Fig. 5.1

SEVEN FREQUENCY DISTRIBUTIONS TO SHOW THE INCREASE IN THE AREA SOWN WITH NEW WHEAT 1965-66 - 1971-72.
1965-66 - 1971-72.



Source: Field work for the Wheat Study - March 1972.

Fig. 5.2

Fig.5.1 illustrates the increase in the area sown to the new high yielding varieties since 1965-66, the year of their introduction to Indian farmers. The Wilcoxon Matched Pairs, Signed Ranks test was used to compare the area of wheat sown in two successive years (1). The increase has been a steady, positive one and the test showed that the area sown by the individual farmers increased significantly each year. Non parametric statistical tests had to be used because the study data are not normally distributed, nor can they be transformed easily. The Wilcoxon test is particularly suitable in this case because the annual samples of wheat sown each year are probably related. The area sown in one year is likely to influence decisions on how much wheat will be sown the following year; consequently, these data are unlikely to be independent of each other, and this fulfils the requirements of the Wilcoxon Matched Pairs, Signed Ranks test.

As the area sown with new wheat increases each year (Fig.5.1), so the frequency distribution of the area curve must also change (Fig.5.2). The Kolmogorov-Smirnov test has been used to find if the frequency distribution of the curve changes significantly as the number of farmers sowing larger areas with new wheat each year increases. Each year was compared with the previous year to see if the change in the form of the curve had been significant (Fig.5.2). A result significant at the one per cent level occurred between 1965-66 and 1966-67 (Figs.5.2. and 5.3). In the year following the introduction of new wheat to Bulandshahr district, 1966-67, the proportion of farmers sowing between 10.1 and 31.6 bighas (0.9 to 2.5 hectares) of new wheat rose significantly (Fig.5.2. and 5.3).

Table of 'D' values from the Kolmogorov-Smirnov test comparing the frequency distributions of the areas sown to new wheat between 1965 - 66 and 1971 - 72.

| <u>Year</u> | <u>'D' value</u> | |
|--------------------|------------------|--|
| 1965-66 to 1966-67 | <u>0.250</u> | |
| 1966-67 to 1967-68 | 0.107 | significant at one per cent level. |
| 1967-68 to 1968-69 | <u>0.104</u> | |
| 1968-69 to 1969-70 | 0.021 | |
| 1969-70 to 1970-71 | 0.019 | |
| 1970-71 to 1971-72 | 0.051 | |

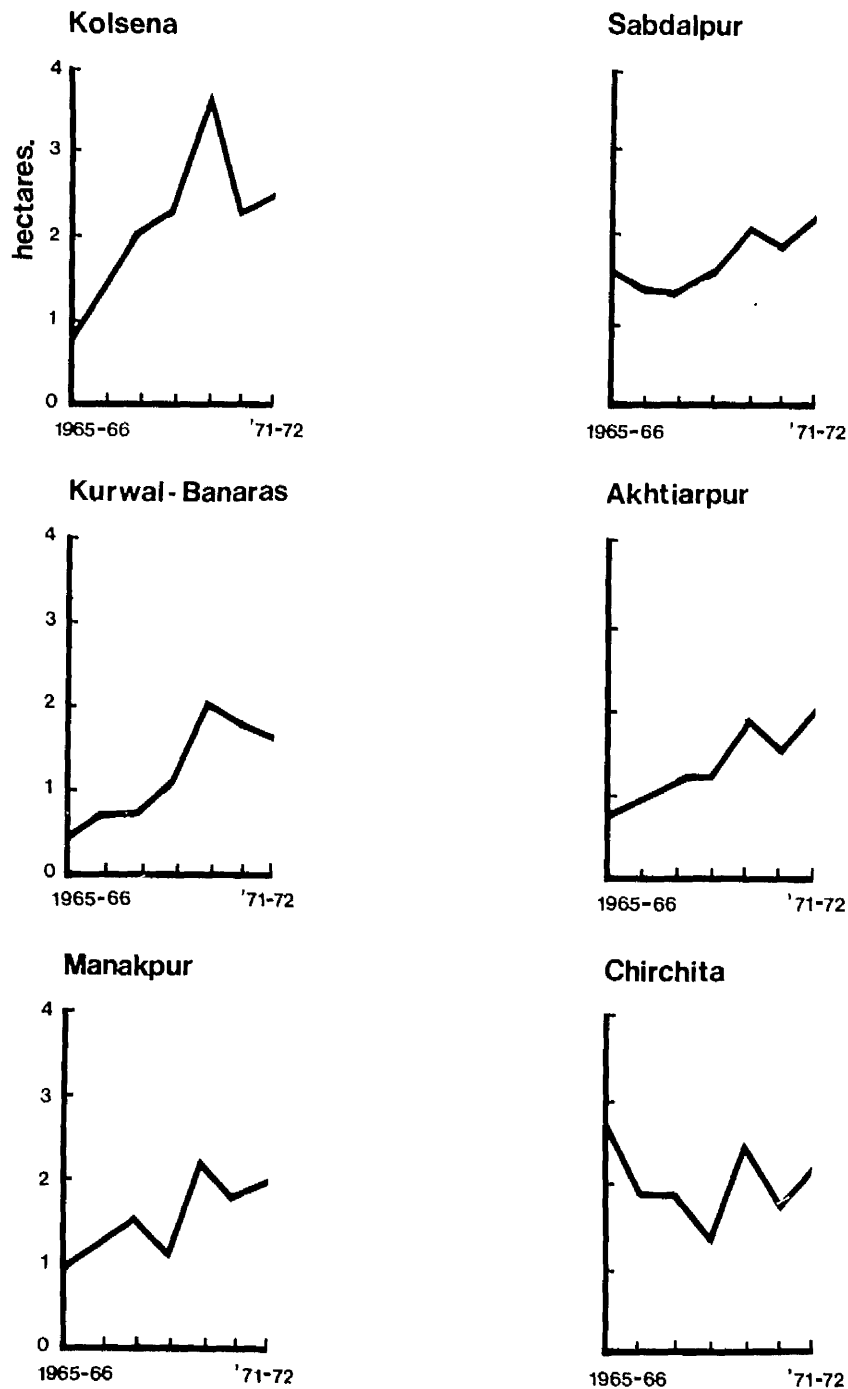
Source: Field work for the Wheat Study - March 1972.

Fig.5.3.

The other significant change in distribution occurred when the mode changed from 10.1 - 31.6 bighas (0.9 - 2.5 hectares) group to the group above it (Fig.5.2). The fall in the number of farmers within the 10.1 - 31.6 bigha group (0.9 - 2.5 hectares) led to a change in the form of the distribution areas sown with the new wheat, and although the number of adopters continued to increase, the form of the curve did not alter significantly. On the first occasion that the Kolmogorov-Smirnov test showed a

A significant change was not found to have taken place between 1966-67 and 1967-68 ($D = 0.107$) (Fig.5.3), for although the 'D' value was greater than in the following year, ($D = 0.104$) (Fig.5.3), the total number of farmers sowing new wheat (N) between 1966-67 and 1967-68 was smaller than in the following season, so the value of the significance level was relatively high as the value of 'N' was lower.

**MEAN AREA OF 'NEW' WHEAT SOWN BY ADOPTERS
EACH YEAR.**



Source: Field work for the Wheat Study— March 1972.

Fig. 5.4

significant change, the positive skew in the curve decreased, and on the second occasion the curve became negatively skewed. (Fig.5.2)

Whether or not these changes are typical of the district as a whole, or are just peculiar to the study area, cannot be estimated. The only study conducted in the area near Bulandshahr which is concerned with the change in the area sown to the new high yielding varieties is the Indian Agricultural Development Programme study in Aligarh, the district to the south of Bulandshahr. In 1965-66, 12,000 hectares were sown to the new high yielding varieties, mainly as a result of demonstration and concerted efforts by extension workers. By the following rabi, the area of the new and hybrid wheat varieties had grown to 74,000 hectares, approximately a quarter of the area sown to cereals during the rabi season (2).

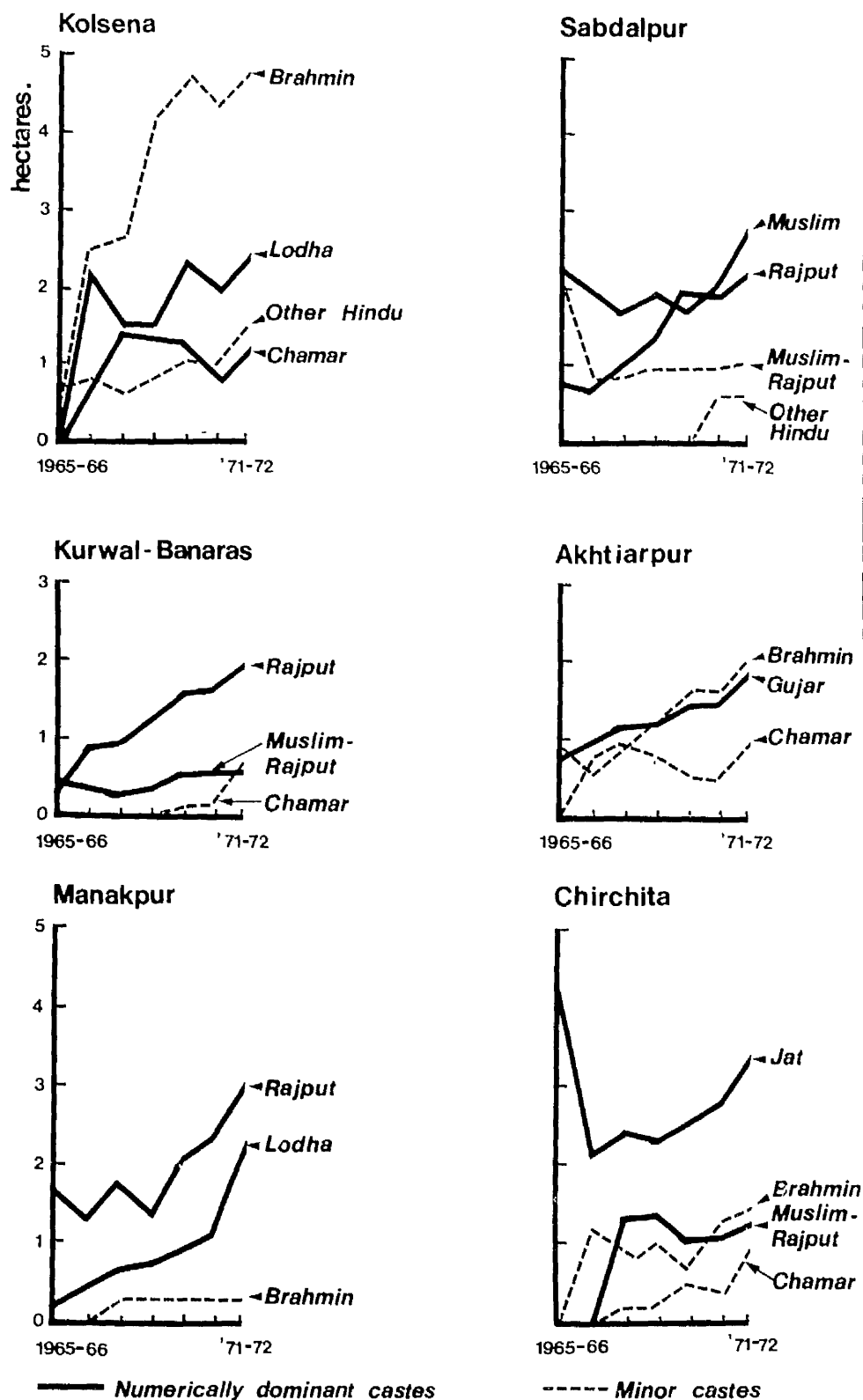
This sharp increase in area found in Aligarh, is not apparent in the study villages (Fig.5.1) except in the village of Kolsena; and so, in order to study the nature of the changes that have occurred, the independent variables, village and caste, will be used as they appeared to be the most significant in the previous section.

As the number of farmers from each village involved in the sample varied, a direct comparison of the statistics was of no value, so the mean area sown to the new and hybrid wheat by the adopters was examined instead (Fig.5.4). The patterns varied quite considerably from the total area sown to the new high

yielding varieties in all six villages (Fig.5.1); this was confirmed by the Kolmogorov-Smirnov test. The trend of the mean area curve (Fig.5.4) is not a constant upward one as the total area sown to wheat shows. In Chirchita and Sabdalpur the innovating farmers sowed relatively large areas to the new high yielding varieties of wheat. As the adoption rate increased, the later innovators began sowing considerably smaller areas to the dwarf varieties and so the mean area fell. Fig.4.10 showed that the late adopters were frequently the smaller farmers and so the periodic decreases in the mean area are probably affected by their presence. 1970-71 is a particular example of this decrease in mean area in every village (Fig.5.4).

After farmers had started to grow the new wheat and the rate of adoption decreased, the farmers sowing the new high yielding varieties began to extend their area and so the mean area sown to the new wheat would rise again. In every village a fall in the mean area sown to the high yielding varieties was preceded by an increase in the number of growers, whereas a rise in the mean area sown to wheat was usually preceded by a period of increasing stability in the adoption rate. This pattern of change in wheat farming emerges from a comparison of Fig.5.4., the mean area sown with new wheat in each village, and Fig.5.1 which shows the rate of adoption of the new varieties by members of all the study villages. The fluctuations in the curves of the mean area sown with wheat in each village tend to become more pronounced after 1968-69, and it is after this date that the majority of smaller farmers, cultivating areas below 32 bighas (2.59 hectares) began sowing the new high yielding varieties. The general trend

MEAN AREA OF 'NEW' WHEAT SOWN BY EACH CASTE IN
EACH VILLAGE.



Source: Field work for the Wheat Study—March 1972.

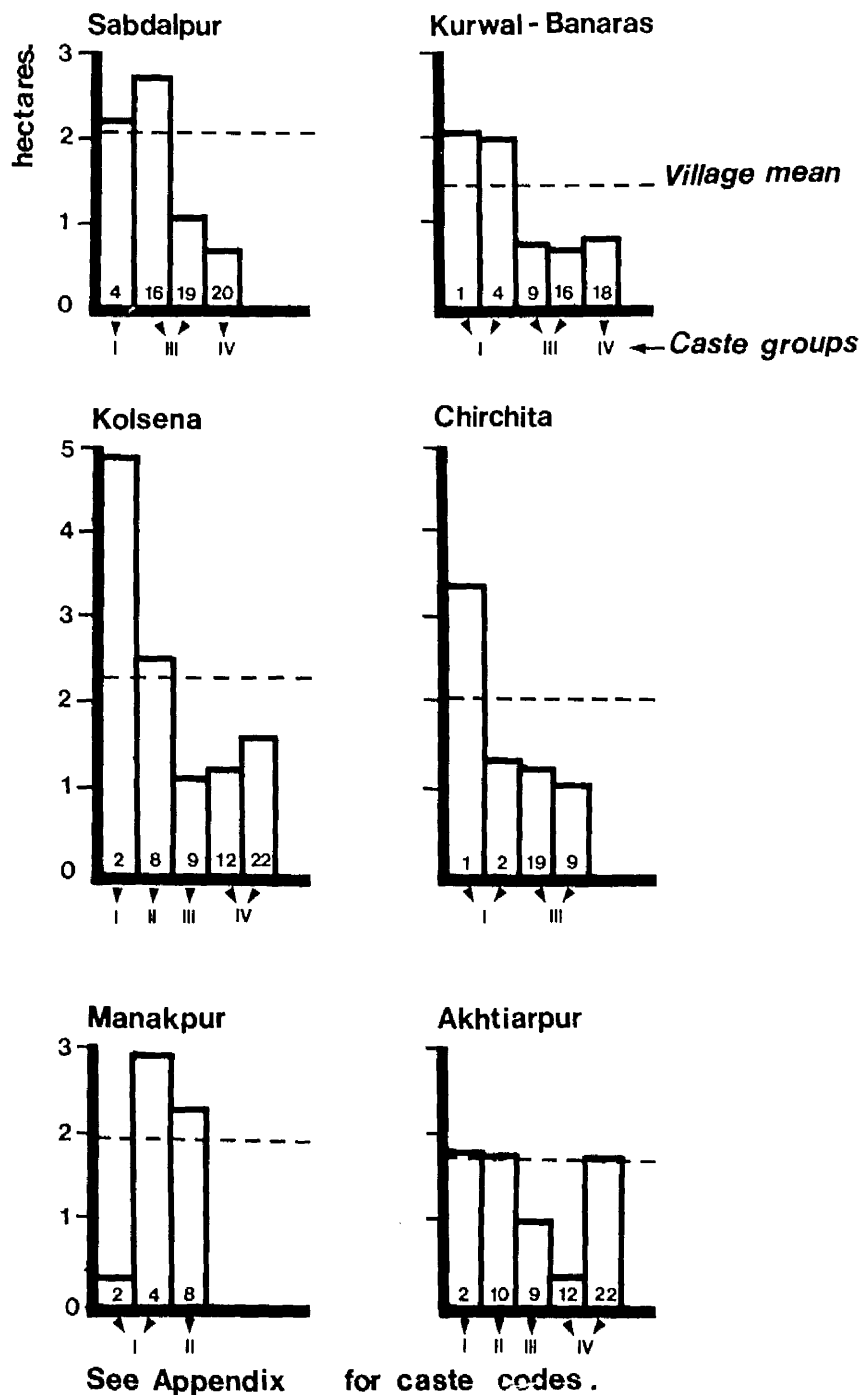
Fig. 5.5

in the mean area sown to the new wheat has been an upward one in each village, despite the fluctuations in the curves which can be explained by the late and often smaller innovating farmers. Chirchita and Sabdalpur are the only exceptions (Fig.5.4).

As the variable 'caste groups within the villages' was related to the rate of adoption of the new varieties (Chapter 4.p.177) the areal wheat statistics were also divided on the basis of this same variable. In almost every case (Fig.5.5), the largest mean area of new wheat was sown by the major caste group in the village, Akhtiarpur being the best example. These findings are borne out by Lipton (1972) (3) who describes similar patterns of majority caste influence as 'casteocracy'. Where two caste groups are approximately equal in numbers (Fig.4.17) the Rajputs and Lodhas of Manakpur, the Rajputs and Muslim-Rajputs of Kurwal-Banaras, the Lodhas and Chamars of Kolsena and the Jats and Muslim-Rajputs of Chirchita, the members of the caste group predicted as having the higher status tend to sow larger areas. These farmers owned the larger farms (Fig.5.5) and are often important members of the village community.

The position of the minority caste groups within a village is never easy to predict. If these cultivators have relatively small sized holdings, that is, below the mean of 43.72 bighas (3.54 hectares), they sow relatively small areas with new high yielding varieties of wheat after a late start (Fig.5.5). For instance, the 'shepherd' in Kolsena, the 'other hindus' in Sabdalpur and the Chamars of Kurwal-Banaras are all members of caste groups III and IV (Chapter 4,p.154). In addition to being

**MEAN AREA OF WHEAT SOWN BY EACH
CASTE COMPARED WITH THE MEAN AREA
SOWN IN EACH VILLAGE .**



Source: Field work for the Wheat Study
March 1972.

Fig. 5.6

members of a minority group, field observation showed that their progress may have been further hindered as their small, dispersed plots were frequently found on the outskirts of the village, or in poorly drained areas where the higher levels of salinity and alkalinity adversely affected potential plant success. In contrast to these members of the lower caste groups are the Muslim-Rajputs of Sabdālpur. They farm areas well above the sample mean and sowed relatively large areas with new wheat in 1965-66. As a result of their larger farms, they are among the more privileged members of the village. The other two minority groups are both Brahmins. Those of Akhtiarpur tend to follow the Gujars who set the pace for the village, while the six Brahmins of Kolsena sow far larger areas with new wheat varieties than either the Lodhas or the Chamars. This pattern is probably due to the large areas of land which they cultivate.

To add further support to the conclusions that the majority caste groups and the 'higher' caste groups grow significantly more new high yielding wheat than the rest, Fig.5.6. shows the mean area sown by each caste in each village, together with the mean area sown by the sample farmers within each village. It could be argued that the median would have been preferable as a measure of central tendency to the mean in both Figs.5.4 and 5.5 (4). Both approaches were examined and it was decided that although the mean might give a biased view due to the influence of extreme values, it did at least take into account every value, whereas the median is based on one case alone and relies on the data being clustered around it. This could not be ensured, so the mean was used instead, but with reservation. The mean area

sown per village shows little variation except in the case of Kurwal-Banaras where it is slightly lower. This could be attributed to neglect by the extension services (Fig.5.4). In Sabdalpur alone, did the Muslims, who are members of caste group III, exceed the mean for the village. In every other case, the farmers of caste group III, the Muslims, Muslim-Rajputs and Chamars, fell below the village mean. Where farmers of caste groups I and II were present in a village, their areas sown with new and hybrid wheat exceeded the mean, except in the two cases of the Brahmins of Manakpur and Chirchita.

Chapter 4 showed that almost all the sample farmers had adopted the new varieties (p.141), and as anticipated, the first part of this chapter has shown that the area sown to new varieties has increased significantly (Fig.5.1), so rejecting the null hypothesis yet again. Chapter 4 also recorded a significant fall in the number of deshi growers between 1969-70 and 1971-72, (Fig.4.20) and the purpose of the next section is to examine the areal patterns of deshi wheat for individual growers and for the community as a whole.

5.2. Changes in the areal patterns of the indigenous varieties of wheat.

While the area under new varieties is increasing, the number of deshi growers has declined in the study area (Fig.4.20), and in consequence, so has the total area under this variety. The declining proportion of the total wheat area of the sample farmers which is sown with deshi wheat is shown in Fig.5.7.

Table to show the proportion of deshi wheat in the total area sown with wheat.

| <u>1969-70</u> | <u>1970-71</u> | <u>1971-72</u> |
|----------------|----------------|----------------|
| 26.75 | 16.00 | 16.30 |

Source: Field work for the Wheat Study - March 1972.

Fig.5.7.

The presence of the reversed 'S' shaped curve is once again apparent (Fig.5.7) though the decrease in the proportion of deshi to total wheat is unequally distributed between 1969-70 and 1971-72. Fig.5.8 illustrates that in Sabdalpur, Manakpur and Chirchita, the major difference occurred between 1969-70 and 1970-71, while in Kurwal-Banaras and Akhtiarpur, the main decline was between 1970-71 and 1971-72. Kolsena was the only village that showed an approximately equal rate of change over the three years.

Table to show the proportion of deshi to total wheat in each village.

| <u>Village</u> | <u>1969-70</u> | | <u>1970-71</u> | | <u>1971-72</u> |
|----------------|----------------|---|----------------|---|----------------|
| Kolsena | 28.56 | * | 18.50 | | 8.89 per cent. |
| Sabdalpur | 16.50 | * | 6.50 | | 4.34 |
| Kurwal-Banaras | 42.10 | | 31.23 | * | 10.01 |
| Akhtiarpur | 22.20 | | 22.30 | * | 9.95 |
| Manakpur | 27.75 | * | 7.12 | | 4.84 |
| Chirchita | 23.75 | * | 12.05 | | 5.92 |

* = period of greatest change.

Source: Field work for the Wheat Study - March 1972.

Fig.5.8.

Kurwal-Banaras and Akhtiarpur still have the largest proportion of deshi wheat of all the villages, but there is relatively little deshi grown anywhere in the study area. This was confirmed by the Kruskal-Wallis non-parametric analysis of variance test which showed no significant difference at the 95 per cent level between the areas sown to deshi in each of the six villages. The question of which farmers are still growing deshi wheat and which farmers have omitted the indigenous varieties from their cropping pattern, still remains to be answered. Deshi growers were classified according to some of the statistically 'independent' variables such as the village identity, caste of the farmer and size of the area farmed, as

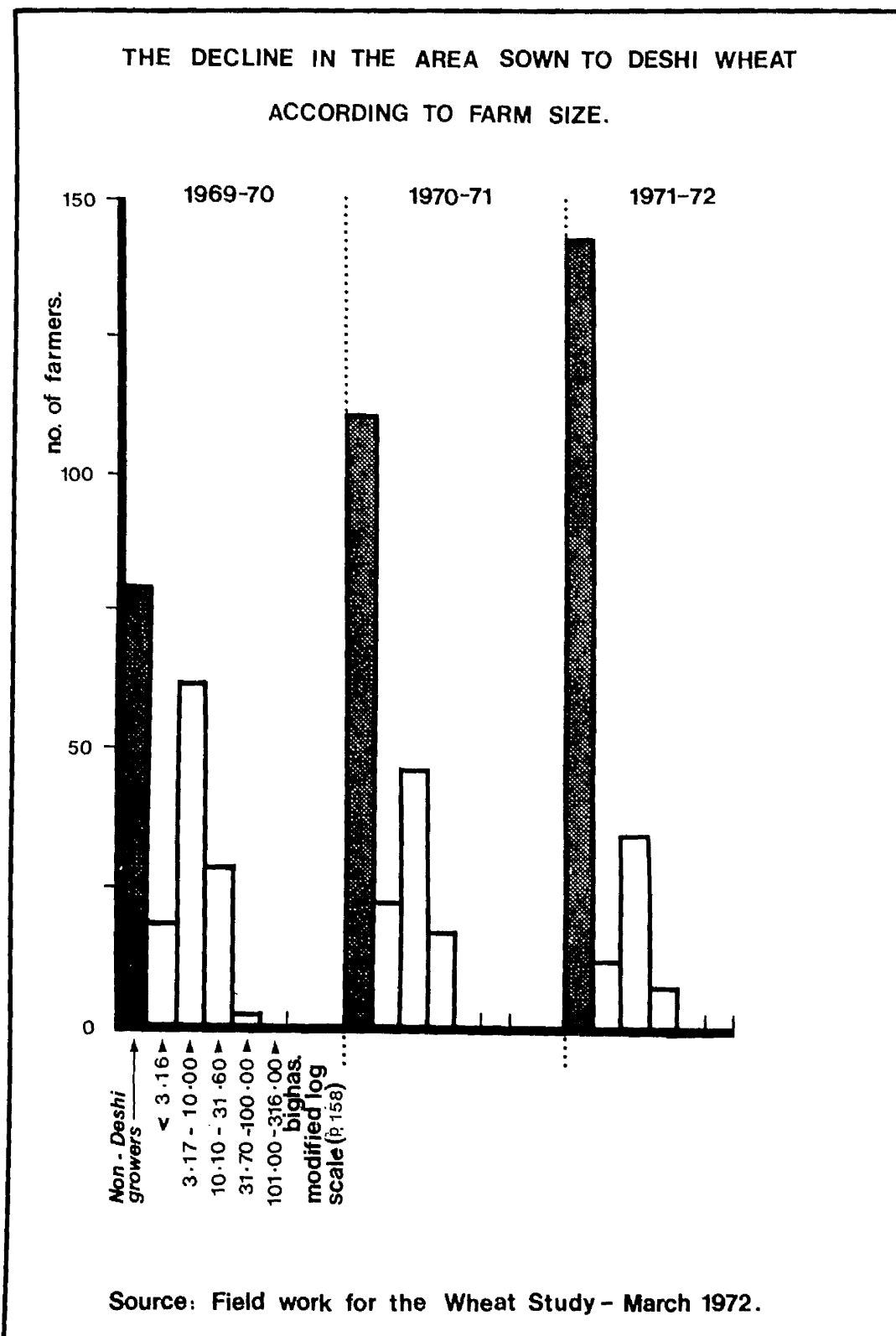


Fig. 5.9

these factors seemed likely to influence the decisions of wheat farmers. Deshi farmers are present in almost every caste in the villages, and the decline in the indigenous varieties does not appear to be a characteristic of any particular village or caste. An analysis of deshi growers according to farm size showed that the three farmers who have not yet adopted the new high yielding varieties, all have holdings below 20 bighas (1.62 hectares). Apart from these three isolated cases, there is no evidence that small farmers are deshi growers in preference to the larger farmers.

Farm size is directly related to the rate of adoption (Fig.4.10) and so the frequency distributions of the areas sown to deshi for each of the three seasons 1969-70 to 1971-72 were compared with the frequency distribution of the area farmed by the entire sample. The Kolmogorov-Smirnov test was used to examine the 'goodness of fit' of one curve with another. There was no significant difference between the distributions of the size of the area farmed and that farmed by the entire sample in any of the three years. If the variables 'smallness' and 'deshi wheat' both pre-supposed less progressiveness, there would have been a proportionately high concentration of deshi growers among the small farmers and the shapes of the distributions would not have been similar, but this was not the case. Fig.5.9 shows the frequency distribution of area farmed for the three rabi seasons 1969-70 to 1971-72.

The frequency distributions of the total area farmed by deshi growers each year were then compared with each other by

the Kolmogorov-Smirnov test to see if the form of the curve changed, and if so, whether the larger or the smaller farmers were responsible for the change in the form of the curve. The proportion of deshi growers fell quite significantly each year (Fig.4.20), but the frequency curves of the area farmed showed no significant change. This indicated that there was a general move away from deshi wheat farming and it was not directly affected by the size of the area farmed.

While the number of deshi farmers has declined significantly (Fig.4.20) and so has the area sown to the indigenous varieties, the mean area sown to deshi both at the level of the entire sample and at village level, has not shown quite such a steep decline, at least, not between 1969-70 and 1971-72, the period for which data were available (Fig.5.10).

Table to show the mean area sown to deshi wheat
by the entire sample.

| Rabi - <u>1969-70</u> | <u>1970-71</u> | <u>1971-72</u> |
|-----------------------|----------------|----------------|
| 10.20 | 7.86 | 6.44 |

Source: Field work for the Wheat Study - March 1972.

Fig.5.10.

The decline in the mean area sown to deshi wheat is probably slowing down because most farmers who sow deshi wheat use it for their own consumption. The profits from the new wheat

varieties are far above those from the indigenous wheat because yields are so much higher than from deshi fields and also because of the guaranteed price from government. The largest areas sown to deshi wheat are certainly on the largest farms, but even on these large holdings, the area does not exceed 30 bighas (2.43 hectares). This deshi crop may well be sold as wheat for 'chapatis'¹. The demand for indigenous varieties is great in urban areas and by 1971 it was a matter of status to eat chapatis made from deshi wheat, particularly if one was not a farmer.

The farmers who grow the new high yielding varieties are the ones who have adopted the new techniques most rapidly, but deshi growers are far from being a surviving relic. On the contrary, many farmers maintain a small area sown with deshi, while sowing the major part of their wheat area with dwarf varieties. Deshi is now considered 'another variety' and there is certainly no indication that deshi wheat growers and less progressive farmers are in any way related.

The decline in deshi wheat is significant, but there is no indication of grouping amongst deshi growers. Whether deshi is grown or not seems to depend entirely on personal preference. It is often grown if the cultivator prefers deshi wheat for his chapatis and is prepared to accept lower returns from part of his farm than if he were to sow the new high yielding varieties. These conclusions are drawn more from the comments of farmers

1. Chapatis - unleavened bread, staple diet in the major wheat growing areas of India.

in the field than the results of the formal questionnaire survey.

Table to show the mean area sown to deshi wheat
at village level.

| <u>Villages</u> | <u>Rabi 1969-70</u> | <u>1970-71</u> | <u>1971-72.</u> |
|-----------------|---------------------|----------------|-----------------|
| Kolsena | 11.90 | 10.85 | 8.10 |
| Sabdapur | 7.20 | 6.10 | 6.60 |
| Kurwal Banaras | 14.30 | 9.60 | 5.25 |
| Akhtiarpur | 8.05 | 7.05 | 6.54 |
| Manakpur | 9.52 | 3.62 | 5.43 |
| Chirchita | 11.80 | 9.50 | 8.50 |

Source: Field work for the Wheat Study - March 1972.

Fig.5.11.

5.3. Changes in the areal patterns of both 'new' and 'old' wheat within the study area.

The farming patterns of the new high yielding varieties and the deshi wheat have both changed considerably since 1965, and the picture of the total area sown to both 'new' and 'old' varieties has been changing in consequence. The statistics for the area under wheat in Bulandshahr district have shown a striking increase between 1969-70 and 1971-72 (Fig.3.18). These data are collected by the District Agricultural Officer from a survey of approximately 80 villages in the district, and they are finally published by the Uttar Pradesh Department of Agriculture in its annual Bulletin of Agricultural Statistics. No attempt in these data to differentiate areas sown to the new high yielding varieties, so no comparisons can be made with the data from the study area with respect to seed varieties.

The areal statistics for both new and indigenous varieties in the study area have not shown such dramatic results as the district wheat statistics. Far from the significant increases in the area sown to both 'new' and 'old' wheat between 1969-70 and 1970-71, the villages of the study area show a decline in the total area sown with both types of wheat (Fig.5.12), though a marked rise is apparent in the areal statistics the following year , 1970-71 to 1971-72.

Table to show the total area sown with wheat in the study area.

| <u>1969-70</u> | <u>1970-71</u> | <u>1971-72</u> |
|----------------|----------------|------------------|
| 336.92 | 303.56 | 404.05 hectares. |

Source: Field work for the Wheat Study - March 1972.

The data were compared by the Wilcoxon Matched Pairs, Signed Ranks test and although the increase in both types of wheat between 1969-70 and 1971-72 was highly significant at the 0.01 per cent level ($z = 2.15$), (Fig.5.13), the changes in the two previous seasons were not significant even at the 95 per cent level of probability.

Table to show 'z' values from the Wilcoxon test illustrating the changes in the area sown to both 'new' and 'old' wheat over the study area.

| 1969-70 to 1970-71 | 1970-71 to 1971-72 | 1969-70 to 1971-72 |
|-----------------------|-----------------------|-----------------------|
| <hr/> | <hr/> | <hr/> |
| 'z' values -0.42 | +1.92 | * +2.15 |

* significant at 95 per cent level of probability.

Source: Field work for the Wheat Study - March 1972.

Fig.5.13.

The total area sown with wheat may have increased significantly, but, analysis according to the village (Fig.5.14), showed that it was the three tube well irrigated villages which had been responsible for the highly significant increases, and that the growth of the new and deshi wheat area was not common to all the villages.

'Z' values from the Wilcoxon test showing the change in area sown to wheat in each of the study villages.

| <u>Villages</u> | <u>1969-70 to 1970-71</u> | <u>1970-71 to 1971-72</u> | <u>1969-70 to 1971-72</u> |
|-----------------|-------------------------------|-------------------------------|-------------------------------|
| Kolsena | -0.84 | +1.65 | +1.38 |
| Sabdulpur | -1.30 | <u>+2.72</u> | +1.64 |
| Kurwal-Banaras | -0.12 | +0.60 | +0.52 |
| Akhtiarpur | -1.28 | <u>+2.41</u> | <u>+2.28</u> |
| Manakpur | <u>-1.97</u> | <u>+2.46</u> | <u>+3.01</u> |
| Chirchita | <u>+3.43</u> | +1.87 | <u>+3.94</u> |

Underlined values are significant at least at 95 per cent level of probability.

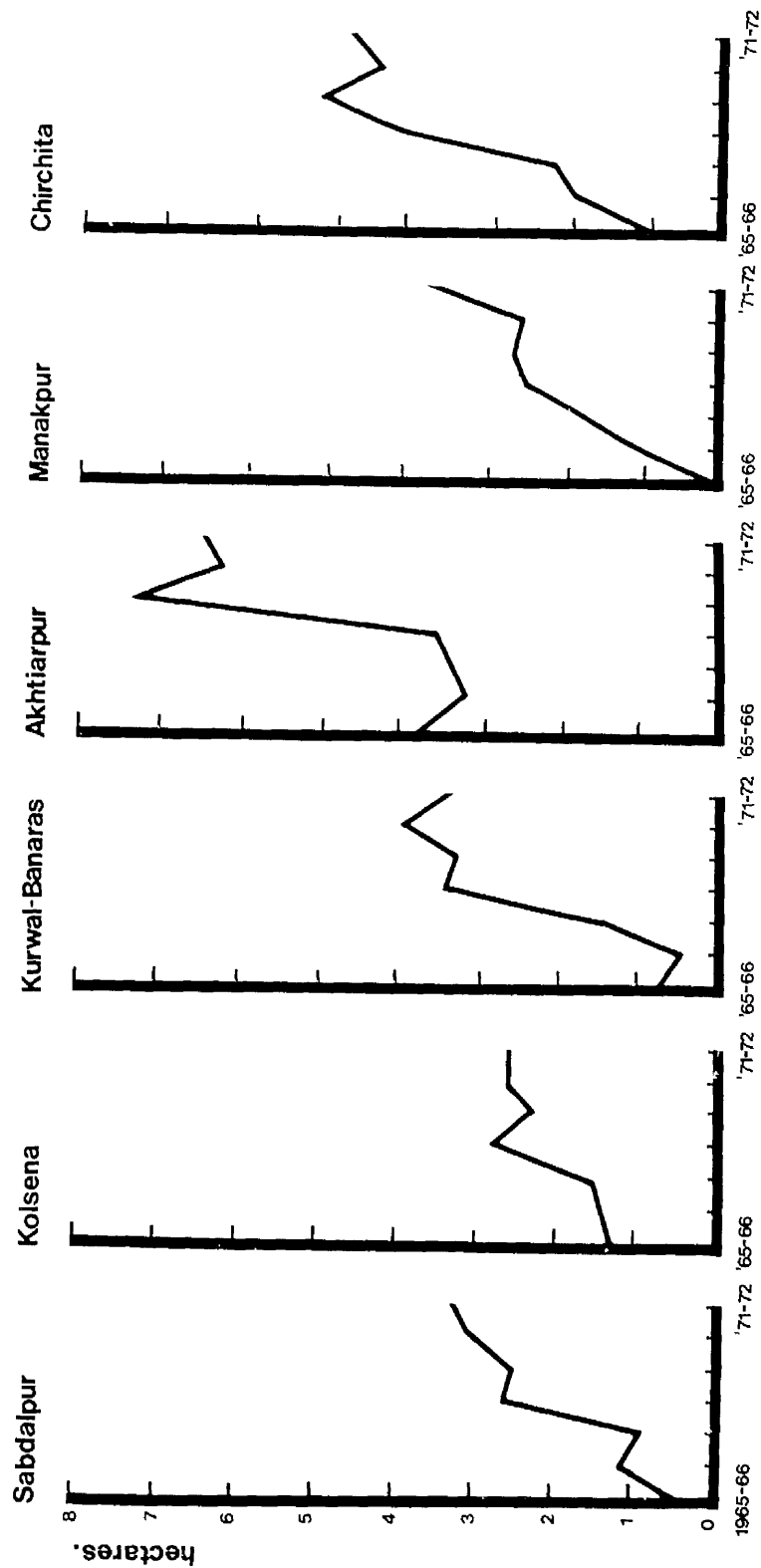
Source: Field work for the Wheat Study - March 1972.

Fig.5.14.

These results from the wheat sample data (Fig.5.14) seemed incomparable with changes at the district scale (Fig.3.18). However, as the 196 sample farmers are representative of such a small fraction of the district, it is not surprising that they did not resemble the mean district conditions. There is much evidence both in the Wheat Study and in the main District Study that individual villages have significantly different characters.

The only other sample data collected for the six villages involved in the Wheat Study were collected by the lekhpals. These officials compiled a variety of statistics relating to the cropping patterns of the village each year. These data are available in varying amounts of detail since 1965, when

THE CHANGING AREA SOWN TO 'NEW' AND 'OLD' WHEAT IN THE STUDY VILLAGES .



Source: Village Khasras 1965-66-1971-72, unpublished.

Fig. 5.15

consolidation of holdings began in Bulandshahr district. Among these are a set of statistics of the changes in the total area sown to wheat. The results unfortunately, are based on a sample of farmers of unknown size and method of selection. According to the official in charge of the khasras, the volumes in which the data were recorded, approximately 20 to 30 farmers were selected for the sample. It is believed that the lekhpals maintained the constancy of the sample from year to year. These statistics sadly, are not used by the district agricultural department in the compilation of the district statistics. As there is no central body which combines the lekhpals' data into any set of statistics which illustrates village characteristics throughout the district, it is not surprising that basic assumptions of each lekhpal on which these data are collected do not conform to a set pattern.

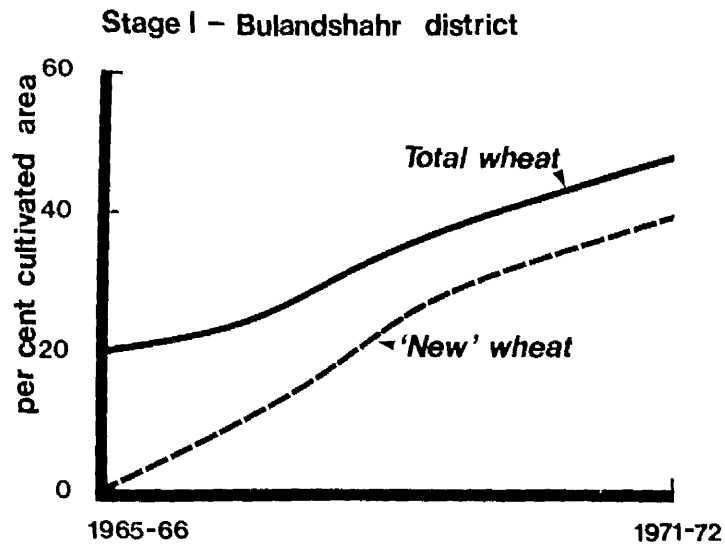
Fig.5.15 illustrates the changes in the total area sown to wheat in each village according to the lekhpals' data. No attempt has been made to examine actual values, but it was felt that trends in the villages should be comparable. The main virtue of these data is that they help to explain the wheat statistics compiled from the questionnaire survey of the 196 farmers. In every village there has been a rapid increase in the area sown to new wheat over a short space of time. The change will not be quantified as the samples from each village are of different and of unknown sizes. This sharp rise at village level is also reflected in the district data (Fig.3.14). In every village the lekhpals' material shows a halt to the increase after rabi 1969-70 and this trend is confirmed by my

own field data. This stabilised trend contrasts with the district areal wheat statistics which have risen significantly in each successive year within this period (Figs.3.14, 5.14, 5.15).

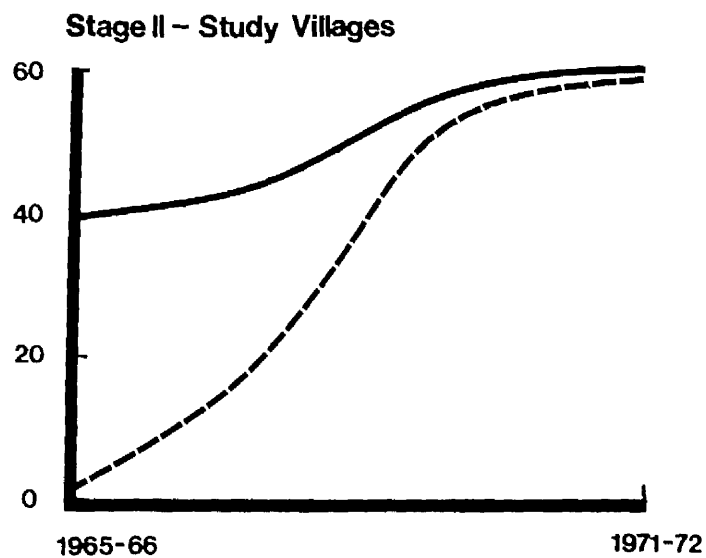
One possible reason is that farmers surrounding Bulandshahr are influenced by the proximity of the district town. All the sample villages were selected within a 16 km. (ten mile) radius of Bulandshahr for easy access. Farmers within this area are fortunate in that problems of access to sources where input materials are available, are few. Although distance does not appear to have a significant effect on the farmers of the six sample villages, there is no reason to assume that it does not have a significant effect at district level. The District Study supports the claims that farmers benefit from living nearer to Bulandshahr and also shows that the farmers of Bulandshahr tehsil, one of the administrative divisions of Bulandshahr district, appear to be some of the most agriculturally progressive farmers in the district. Innovation in the villages of the study area appear to have reached the top of the 'S' shaped curve where change is less rapid. The district as a whole which contains the extreme elements of the population, show a continuing increase in the area sown to wheat, most probably representing the situation of the majority within the district.

Both primary and secondary source material appears to show two stages in the change from 'old' to 'new' varieties of wheat. The first is a period of increase where the higher yields of the new dwarf varieties encourage farmers to increase the areas they are sowing to wheat. Although no quantitative information

MODEL OF CHANGE IN AREAL WHEAT PATTERNS,
BULANDSHAHR AND THE STUDY VILLAGES.



Source: Discussions with district
agricultural officers, 1972.



Source: Field data - 1972 .

Fig. 5.16

is available, it is likely that the proportion of deshi wheat was still high during this period. The first stage is represented by the district statistics (Fig.5.16.stage 1). Gradually, as they gained confidence in the new high yielding varieties, they replaced the traditional wheat with the new dwarf types. This process of replacement of 'old' wheat by 'new', has restricted the growth in the total area sown to wheat. This situation was apparent in the study area (Fig.5.16.stage 2), and suggests the possible future trend for the district as a whole. The farmers of the Wheat Study are members of the agriculturally progressive Bulandshahr tehsil according to the District Study (1972), and so it is to be expected that they are representative of stage 2. Having increased their area of wheat land they are now replacing their traditional varieties with the highly productive Mexican dwarf and indigenous hybrid wheats. These are the main changes in the areal patterns of wheat farming and further reject the claims of the initial null hypothesis that wheat farming patterns have seen no significant change. These modifications in wheat farming patterns since the introduction of the dwarf varieties is likely to have a far reaching effect on the entire cropping system and this will be discussed in the following section.

5.4. Changes in cropping patterns within the study area.

The high yielding varieties have a shorter life cycle than their indigenous counterparts and this gives the farmer the opportunity of growing more crops on his land each year . The High Yielding Varieties Programme urges him to do so. This section of the chapter looks at the cropping patterns of the farmers within the Wheat Study area to see whether they are benefitting from the high yields of the new wheat by merely increasing the area under cultivation, or if they are deriving the maximum benefit from the new varieties, by adopting multiple cropping schemes as well. Wheat, the most popular of the new varieties in the study area, is not grown in isolation. Traditionally sown together with mustard, barley or jai, it is only part of the rotation system usually involving two and sometimes three crops in an agricultural year.

Experimental crop rotation systems at Bulandshahr Agricultural College.

Approximate ^w sowing dates.

| <u>20th April</u> | <u>20th June</u> | <u>25th September</u> | <u>15th. December.</u> |
|-------------------|------------------|-----------------------|------------------------|
| moong | maize | potatoes | wheat |
| moong | paddy | thoria | wheat |
| moong | maize | thoria | wheat |
| moong | maize | potatoes | potatoes |
| moong - lentils. | | thoria - rape. | |

Source: Principal of the Agricultural College, Bulandshahr -1972.

Fig.5.17.

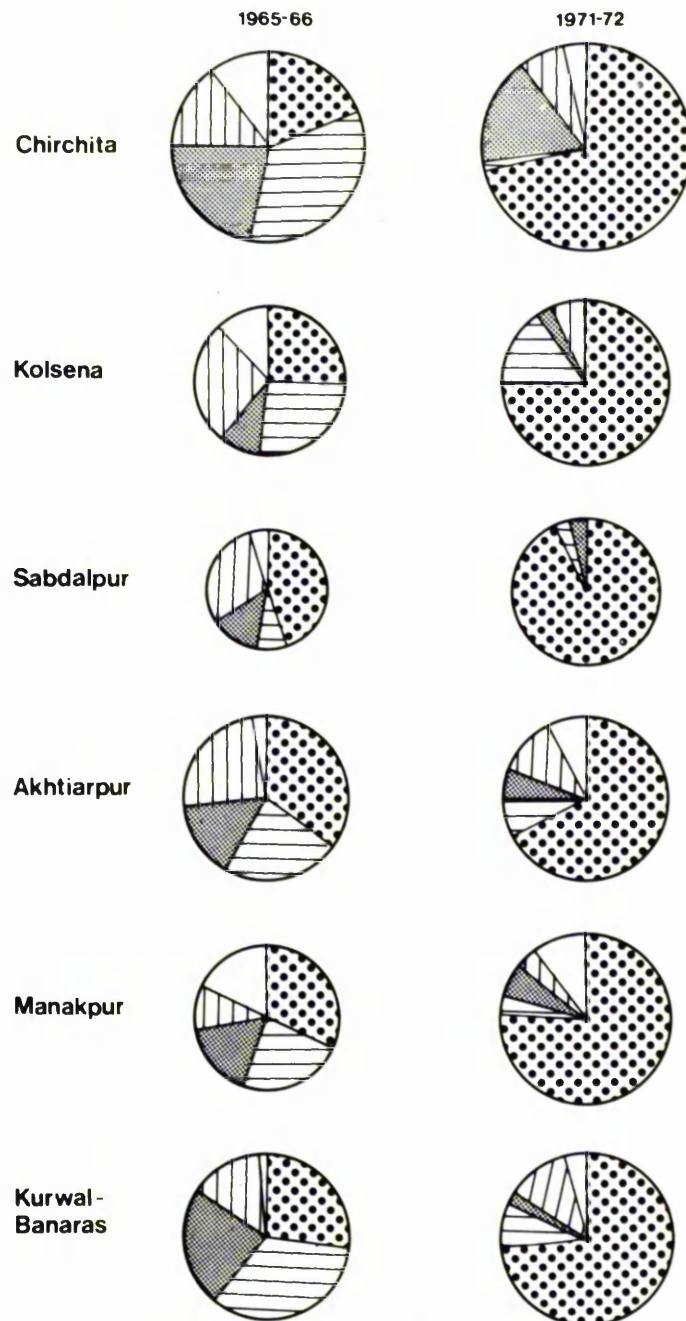
The high yielding varieties of wheat mature in approximately 120 days while the traditional varieties take 140-150 days to ripen properly. This reduction in the maturation period, together with the development of early and late varieties gives the crop rotation system greater flexibility. The farmer could harvest as many as four crops from his fields in a year, and experiments of the Agricultural College in Bulandshahr have shown that this is possible. The relay cropping rotations they have found to be successful are summarized in Fig.5.17. Their system involves three cropping seasons; the kharif or autumn season from July to late September or October, during which maize, rice and millets are the main crops. This is followed by the rabi season, and the spring harvest of wheat, barley, gram, pulses and potatoes, is gathered in late March. A third quick crop of onions, water melons, chillies, tobacco or certain lentils can be taken immediately after the rabi during the zaid, but relatively few farmers take advantage of this season when annual temperatures are reaching their peak. According to the Principal of the Agricultural College, Bulandshahr, by sowing late wheat, an extra crop could be harvested at the end of the kharif. Experimental work has shown that potatoes or thoria, Brassica campestris (rape) filled this role suitably, but when extension officers had broached the subject with farmers, they had been far from enthusiastic about it.

Since the high yielding varieties have been introduced, the farmers have been urged to use multiple cropping techniques so that agricultural production could be increased. The high yielding varieties lend themselves to relay cropping in particular, and so

traditional methods of inter cropping were rejected as these led to lower crop yields. It is only very recently that the benefits of inter cropping have been further investigated (5). Although growing more than one crop at a time may lead to lower yields, as soil nutrients have to be shared, certain crop combinations are being established which will make weed control easier, reduce attack by pests, and raise the overall yield per unit area. These ideas of re-introducing inter cropping were very new in the study area at the time of the Wheat Study, and for the most part, the emphasis of the extension agent was on relay cropping.

The cropping patterns of farmers in the study area were examined to see if the number of crops harvested each year had increased since 1965. Unfortunately these data could not be collected by formal questionnaire, because the pilot study had shown that farmers were unable to recall their rotation system of earlier years with any degree of accuracy. The alternative source of this information was in the khasra, one of the sets of records compiled by the lekhpal for each village. An attempt was made to obtain data for those farmers specifically involved in the Wheat Study, but this was not possible because farms belonging to one individual may be registered in several names. A similar problem was encountered when preparatory lists for a stratified random sample of farmers were being made for each of the study villages. The problems and drawbacks of the method are fully discussed in Appendix 1.4. The only alternative was to use crop rotation data for the entire village. The cropping system of individual farmers was examined, but these showed no significant

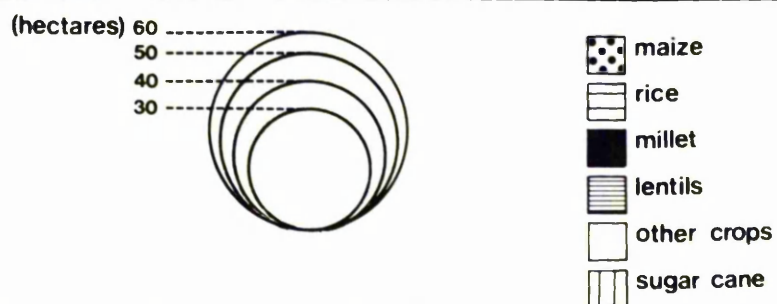
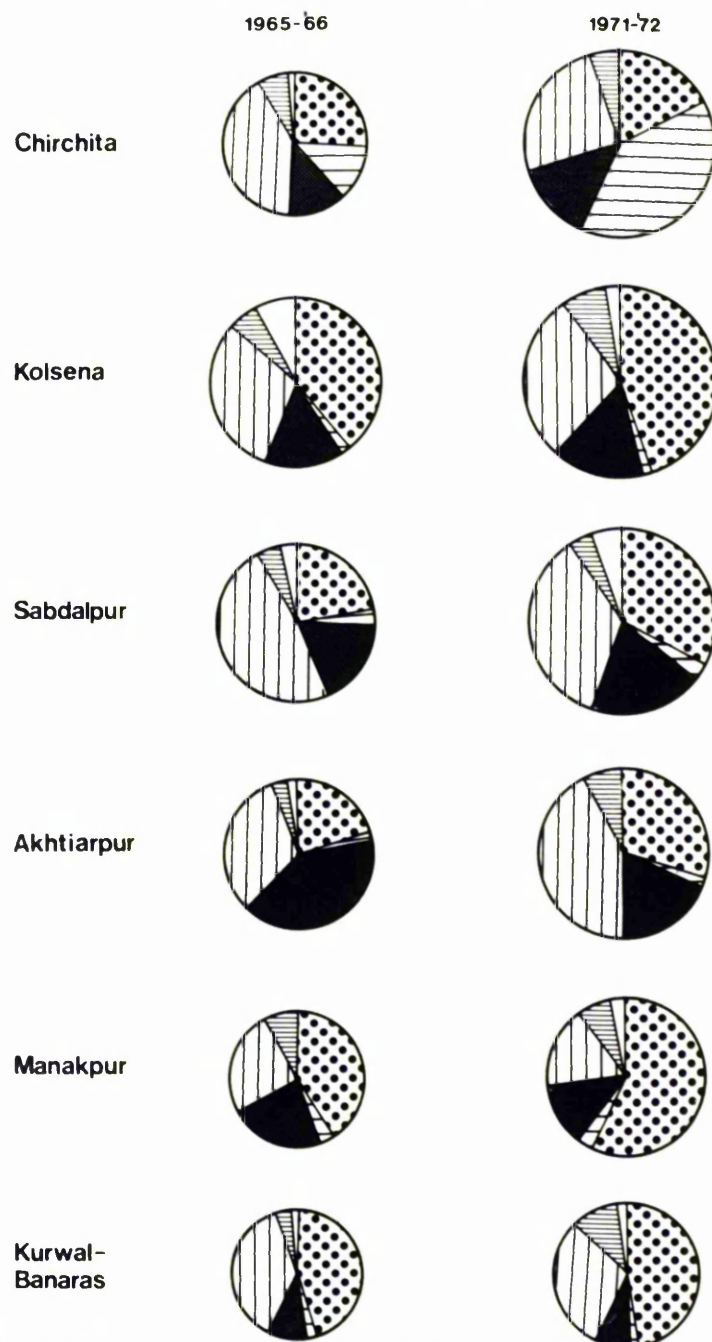
CHANGING IMPORTANCE OF THE MAIN RABI CROPS
IN EACH VILLAGE BETWEEN 1965-'66 AND 1971-'72.



Source: Village Khasras 1965-66 & 1971-72, unpublished.

Fig. 5.18

CHANGING IMPORTANCE OF THE MAIN KHARIF CROPS IN
EACH VILLAGE BETWEEN 1965-'66 AND 1971-'72.



Source: Village Khasras 1965-66 & 1971-72, unpublished.

Fig. 5.19

differences. Almost every farmer grows two crops in a year which is progressive, as in 1971-72 only 20 per cent of the total irrigated area in India was double cropped (6). The main aim of the multiple cropping programme was that a minimum of two or three crops should be grown each year. In the study area none of the farmers harvested less than two crops, though a very insignificant proportion took three crops each year.

Figs.5.18 and 19 summarize the change in the proportionate area devoted to each crop in each village between 1965 and 1971. These are the most recent data available and show that there has been relatively little change in the total sown area each season. In the rabi, the spring season, the largest area is cultivated and this is reflected in the district level statistics (Fig.3.11) where the cropped area of the rabi is far in excess of land cultivated during the kharif. These two seasons are by far the most important while the zaid does not occupy a significant position in the cropping pattern at all. There has certainly been no significant increase in the number of crops per year since the introduction of the new high yielding varieties, and from discussion with the farmers, they had no intention of incorporating a third crop into their rotation, let alone a fourth as was suggested by the Principal of the Agricultural College, Bulandshahr.

As Figs.5.18 and 19 show, there is relatively little variation in the cropping patterns of the villages. Predictably, wheat is the major rabi crop while maize occupies a similar position in the kharif. There have been no major changes in the

cropping patterns within any of the villages, but since the introduction of the new high yielding varieties in the mid 1960s, there has been a notable increase in the area sown with wheat and maize in particular, though the area of jowar has been increasing and, according to the farmers, this is due to the improved indigenous varieties which have been produced.

The major crops are the same in every village, but it is among the less important varieties that one can see the pattern vary from village to village. The area sown with barley, for instance, has declined considerably since 1965 in Akhtiarpur and Manakpur, but has maintained its level in Kolsena. This is probably because barley requires relatively little water in comparison with wheat. It is only since 1965 that irrigation water from tube wells has been available in these villages and, as it is more profitable, the farmers have chosen to grow wheat in place of barley and gram. A similar pattern was also noted at district level (Fig.3.18) and a comparable pattern of change has also been identified in the Punjab (7). The canal villages of Sabdalpur, Kolsena and Kurwal-Banaras have maintained a relatively constant wheat and barley pattern, as they have experienced little change in their irrigation facilities in recent years.

In 1971, rice sown in the kharif showed considerable increase in area and dominated the kharif crops in Chirchita. Its progress is more variable than in the other villages, but in Manakpur, for example, the area sown to rice has decreased. According to the village lekhpal of Manakpur, yields of rice

in the village were not satisfactory due to disease. In absolute terms rice has declined in every village since 'new' rice reached a small and insignificant peak in 1969. The decision to sow less rice seems to be common to a village as a whole and so one tends to find more inter-village differences than intra-village variation in the crop rotation patterns. Farmers in each village tend to conform to a pattern. This was clear from the crop data collected for each farmer in the khasra. There is no significant variation within a village.

Most of the other crops such as the various pulses and chillies, for instance, have changed little since 1965 and still occupy a very insignificant part in the rotation. They are mainly grown for the farmers' consumption and so are sown when the family's reserves have come to an end.

Previously, it was common to sow two crops together in a field particularly in the rabi. In the study villages, rows of wheat were alternated with gram, mustard or jai and barley. Crops like mustard and jai, and to a certain extent gram, gave support to the tall indigenous varieties of wheat and prevented them from lodging. Mustard and jai with their tall branches often grew as high or even higher than the deshi wheat, and gave it considerable support. These crops are harvested at the same time or within a few days of each other and so they share the nutrients in the soil. The tall thin strawed indigenous wheat varieties could not support too heavy a head of grain, and with a relatively small supply of soil nutrients available, the production of heavy ears of wheat was unlikely.

With the new high yielding varieties the situation is completely different. The plants are short and stocky and have less tendency to lodge. In theory it is preferable that they are grown alone as an adequate nutrient and water supply is essential for the production of high yields. Many farmers, however, still plant jai, mustard or gram with the wheat, but it is becoming less common as there has been a movement away from inter cropping since the introduction of dwarf wheat. Informal conversations with the farmers in the field showed that they still felt it was worth while cropping jai or mustard with wheat without causing the latter too much harm. If for any reason the wheat failed, at least one crop was likely to survive.

Inter cropping techniques have long been in use in India, and as the change to relay cropping has not been met with overwhelming success, research is now being directed towards establishing the most rewarding crop combinations (8). Although yields are generally higher under relay cropping, the overall yield per unit area is higher under inter cropping because more crops can be grown. In consequence this age old concept of inter cropping is now being re-introduced to the somewhat confused farmer as an alternative to the 'new' relay cropping.

As the practice of taking two crops simultaneously during the rabi is still popular with the farmers of the district, agricultural extension workers from the Bulandshahr Agricultural College began in 1971 to teach the benefits of planting sugar cane among the wheat. This is the chief cash crop of the district. It can be sown between the rows of wheat in November, but unlike

mustard and jai is harvested the following November. Sugar-cane is very demanding on soil nutrients, but according to the Principal of the Agricultural College, Bulandshahr, its major period of growth occurs after the wheat has been harvested. If the supply of chemical fertilizers to the wheat fields is adequate, the sugar-cane does not significantly affect the success of the wheat, and itself greatly benefits from the quantity of chemical fertilizer available and also from the irrigation water which is essential for both crops. Growing both wheat and sugar-cane together does economise on irrigation water to a small extent. Farmers are only just beginning to sow these two crops together. Out of 196 farmers involved in the Wheat Study in March 1972, five were growing sugar-cane and wheat in Chirchita and two in Akhtiarpur. By March 1972 there was no evidence of this crop combination in any of the other villages.

Sugar-cane has been included in Fig.5.20 even though it is not a food crop nor is it confined to a single season. Bulandshahr was the main sugar producing district of the doab in 1971-72 and the emphasis on sugar by the extension workers is to avert any disaster should a glut of wheat occur due to significantly higher yields from the new wheat. In the Punjab similar precautions are being taken and farmers are being prepared to diversify their crop routine and sow oil seeds, jute and cotton (9). Should there be an excess of wheat, the north Indian plains would suffer badly. As sugar is the main cash crop of the district, it was felt justifiable to include it in a discussion of crop rotation patterns together with other less important cash crops such as cotton.

A word must be said about the crops of the zaid. In the study villages water melons, tobacco and onions are the three most popular crops but only nine farmers out of 668 whose rotation patterns were registered in the khasra grew a summer crop. The main complaint against working during the zaid was the extreme heat and a tradition of having rested between the end of the rabi and the beginning of the kharif. The new high yielding crop varieties are much more demanding on the farmers' time than were the comparable indigenous varieties (Chapter 4) and, as many of the farmers, particularly those with holdings below the mean size of 43.72 bighas (3.54 hectares) grow crops purely for their own requirements, they have no need to increase their output beyond a certain limit. It is uneconomic for them to market a small surplus. According to several of the farmers, production and transport costs barely make it worth their while to increase their output marginally.

Cultivators involved in the questionnaire study found it difficult to picture a rotation which involved a quick potato crop followed by a late wheat harvest and so involve a third crop in their rotation without farming in the zaid. Very few were even prepared to consider the idea of planting a summer crop and were not willing to change their present cropping system, as the additional effort necessary during the hot months was felt to exceed the value of the returns. They were not so averse to the idea of inter cropping however, as this fitted in with traditional patterns and involved little extra output in terms of effort.

That part of the High Yielding Varieties Programme which involves increasing the agricultural output by increasing yields has succeeded in the study area as farmers have readily adopted the new seeds (Chapter 4.p141), and as a result are harvesting well above average wheat yields for the district (Chapter 7 p.309) The response to increasing the agricultural output by increasing the cultivated area has been slight in the six study villages of the district, but it must be said that there is barely any new land available for cultivation. Three quarters of the district was cultivated in 1972 and this figure has increased little since the countryside felt the impact of the canals in the mid nineteenth century. Farmers have not been averse to increasing their cultivated area, it merely has not been possible for them to do so. Land previously devoted to other crops such as barley, gram and pulses is being sown with seed of the new high yielding varieties, and so the area of high yielding varieties, particularly wheat and maize has increased even if the total cultivated area has not grown significantly.

Local farmers of the study area have shown considerable enthusiasm for these new varieties and so have responded to the first two demands of the High Yielding Varieties Programme. The third section of the programme which envisages increased production by multiple cropping, especially by relay cropping, is not nearly so popular and many cultivators thought that the returns from a third crop relative to the effort and cost of its production were not really worth while. They preferred to concentrate on the existing two seasons and especially on the rabi as returns from this season were highest. Perhaps a policy

of multiple cropping by inter cropping could be more successful in this area. To conclude this section of Chapter 5 it is true that there have been few radical changes in crop rotation patterns. Rather than introduce an extra crop each year, farmers of the study area have replaced their lower yielding crops by the high yielding varieties and so the pattern is one of change within the seasons rather than among them.

5.5.

Conclusion.

The growing number of adopters of the new varieties of wheat (Fig.4. 2), the changes in the varieties sown and the increase in the area planted with them all, provide evidence for the rejection of the first part of the null hypothesis that change had been insignificant (Chapter 2.p.59). It was only the cropping systems in the study villages that showed no marked change, but in every other case changes in the farming patterns examined in Chapters 4 and 5 were quite pronounced and in keeping with the aims of the High Yielding Varieties Programme.

These patterns of adoption however, are not adequate indices of the success of the new wheat farming technology, it is only if the yield potential of the new varieties can be realised and maintained that Green Revolution supporters have the right to class the new varieties as a success in a particular area. The purpose of the succeeding chapter is to examine in detail the methods farmers are using for growing their new wheat, and an attempt will be made to assess the adequacy of these methods in the light of recommended farming techniques for the study area.

CHAPTER 6.

Changes in selected wheat farming practices since the introduction of high yielding varieties.

The new high yielding varieties of wheat have very different ecological requirements from the indigenous wheat. Among their many differences they require higher inputs of fertilizer, water, insecticides and pesticides, and so are much more demanding on the farmers' time than were the indigenous varieties (1).

The cultivator has to adapt to a completely new farming routine and needs to understand the differences between the plant life-cycles of the new and indigenous varieties. The differences will be fully discussed later in the chapter. Traditional agricultural practices have been instilled into the cultivator through generations of rural life and the use of certain techniques has become almost instinctive. The approach to farming the new high yielding varieties is much more scientific, and although the crops can tolerate a wide range of physical conditions, yields will not be as high as they might be unless the numerous input demands of the plant are understood and provided (2).

Several of the new varieties can be grown in areas of different elevation, soil type, climate and day length, and consequently their expansion at a national level is much easier than if they had the comparatively small tolerance ranges of the indigenous varieties.

If the farming techniques suit the new varieties, they are much more tolerant of a wide range of physical conditions than are the indigenous varieties. But if, on the other hand, the new varieties are not provided with all their physical requirements,

Mr.V.S.Mathur, Chief wheat breeder at the Indian Agricultural Research Institute, Delhi confirmed that their productivity might fall below that of the indigenous wheat, and consequently produce 'mediocre' yields. The new varieties tend to be much more extreme in their reaction to the farming techniques used in their cultivation than are the deshi varieties.

Little information is available on the techniques farmers are using for growing the new high yielding varieties. The Intensive Agricultural Development Programme (IADP) and the Intensive Agricultural Areas Programme (IAAP) districts collect copious data on farming methods, but the majority of this material is used for descriptive purposes and not for research into the methods of farming the new high yielding varieties at all (3). The Ministry of Agriculture has produced a set of 'rules' for growing the new high yielding varieties successfully, called the 'package of practices'. The intention of the government is that a set of these rules should be compiled for every state and district to take into account the physical differences which may occur in the landscape. Though the plants have wide tolerance ranges, habitat factors are apt to vary, and plant productivity could well be improved by minor modifications in the farming routine. The Principal of the Agricultural College at Bulandshahr provided details of the package of practices taught to extension workers in the Bulandshahr district. There only seemed to be published versions of the package of practices available for states which were agriculturally well known, such as the Punjab. No published version of the package

of practices was available for Uttar Pradesh and all information was taught to the village level workers of the extension service, who teach local cultivators the 'scientific approach' to wheat farming. In theory, one copy should be available for reference purposes in all the areas involved in the High Yielding Varieties Programme, but the 'package of practices' for Bulandshahr district was not published and the only copy to be found was for the Punjab. No information on the success or failure of the farming techniques applied to new wheat is available except for experimental areas such as the districts of the Indian Agricultural Development Programme and the Intensive Agricultural Areas Programme, where results are often far higher than non-experimental areas (4). One of the main purposes of publishing these results in the Annual State Bulletin of Agricultural Statistics is to promote the government's High Yielding Varieties Programme(5).

The only indications of the level of success of wheat farming are the yield estimates published in the Annual State Bulletin of Agricultural Statistics. These do not differentiate the yields of the new high yielding varieties from the indigenous wheat, but if in Bulandshahr 83.79 per cent of the total wheat land was sown with dwarf varieties in 1970-71 as the Lead Bank Survey suggested it was (6), the mean value for the district wheat yields ought to have been higher than 14.48 quintals per hectare (7) in 1970-71, when the potential of the new varieties was about 40-50 quintals per hectare (8). The 1970-71 statistics are the most recent figures for the district and the proportion of the sample area sown with the new wheat in rabi 1971-72 is 95 per cent, which is even higher. The district statistics are all based on estimates made from about 300 crop

cutting samples collected by the district agricultural department (9), and the extrapolation of these results to district level is not a satisfactory index of the level of success of the new high yielding varieties of wheat in the district . Fig.3.17 shows the changes in wheat yield per unit area since 1965-66 in Bulandshahr district. Yields have risen, but in comparison with the marked rises in such variables as water and fertilizer inputs (Figs.3.7 and 3.27), the increase in yield seems unimpressive when one considers that 83.79 per cent of the district's total wheat area was under the new high yielding varieties in the rabi season of 1970-71, the year before the study was carried out (10).

The purpose of this chapter is to examine in some detail the new farming techniques associated with the new high yielding wheat. It is doubtful whether all the farmers sowing dwarf varieties have an equal ability to accept, understand and put into practice the changes that are necessary in the farming routine. The first aim was to see whether the traditional approach to farming had been modified; and the second was, if it had, how closely did the new farming techniques compare with the farming methods which best suited the new wheat. The answers to these questions would show which farmers were prepared to be flexible, and also whether or not they had grasped the 'message' of the village level extension workers.

The best way to examine these questions seemed to be to compare certain techniques farmers were using for growing both the new and the traditional varieties of wheat. This would

indicate whether methods had changed from traditional practices. The second question will be tested by comparing the present techniques of the farmers with the recommended package of practices for the area, as these rules have been chosen to provide conditions as close as possible to the theoretical requirements of the plants. In this chapter we shall examine the claim of the major null hypothesis (Chapter 2.p.59) that there has been no significant changes in farming techniques and that the ecological demands of the varieties are not being adequately met.

Several farming techniques needed to be changed with the introduction of the new high yielding varieties, and so a list of a selected number of these techniques was compiled and they are listed below. The decision to include these particular variables associated with wheat farming was entirely the result of observation and qualitative information collected in the field. Where the data have been analysed statistically, these variables have acted as the statistical 'dependent' variables in this chapter.

Dependent variables associated with wheat farming which vary when the new high yielding varieties are grown instead of the indigenous wheat.

1. Land preparation.
2. Seed preparation.
3. Fertilizer application.
4. Irrigation.
5. Insecticide and pesticide.
6. Harvesting and marketing.

A second group of variables which seemed likely to influence the variables listed above was also compiled in a similar way. These have been used as the 'independent' variables when the data have been examined statistically.

Statistically independent variables.

1. The village identity of the farmer.
2. The caste of the farmer.
3. The caste groups in each village.
4. The area cultivated by the farmer.
5. The farmer's main source of irrigation.
6. The education level of the farmer (7) : the year of his instruction in new farming techniques.

The strong inter-relationships between these 'independent' variables were fully discussed in Chapter 2.p.71 ,& App.4, as the variables are not truly 'independent' in the statistical sense. With this major reservation in mind, non-parametric statistics only will be used to indicate whether the relationships between combinations of both sets of variables are significant. As the 'independent' variables are not mutually exclusive, the extent of the relationships cannot easily be quantified and this further justifies the use of non-parametric tests which indicate the presence or absence of a relationship without giving a measure of its strength.

Land preparation.

The soils of the study area are clays, loams and sandy loams (11), and by the end of June, the Indian summer season, they are very dry and hard. The heavy and sometimes torrential rains of the monsoons cannot all percolate through to the lower layers of the soil, nor can they run off easily because the land is so level. (The entire district slopes only 28.13 cm. in one km. - 18 ins. in one mile - (12)). The high temperatures evaporate the water and cause capillary action in the soil. In this way the less water soluble salts of iron and aluminium are brought to the surface and deposited (13). These reduce permeability of the soil to water even further. The absence of organic material and soil fauna prevents the surface layers from being disturbed, and so, by the end of the monsoon, when preparation of the rabi season is about to begin, the surface often looks as though puddling has taken place; it is almost impenetrable.

Ploughing the soil for the rabi is often a difficult task. At least four ploughings are necessary, because the traditional wooden plough with a metal spike is used. The maximum depth to which this can penetrate is 20 cm. Wheat is dependent on water to a depth of about one metre (14), so the surface has to be adequately broken up to permit any winter rain and irrigation water to penetrate to the lower levels. The wooden plough cannot penetrate the soil as deeply as mechanically driven ploughs, but as long as the surface layers are disturbed sufficiently to destroy the first stages of an iron pan, wheat can be grown successfully.



Plate 11.

The traditional method of ploughing.

Source: Field work for the Wheat Study - 1972.

Work which shows the utilisation of water by wheat to a depth of one metre or more (15), often refers to land that has been mechanically ploughed, but in the Wheat Study area the soil was rarely disturbed below a depth of 20 to 25 cm. Being of the family Gramineae, wheat can spread its roots laterally if penetration to great depths is not possible. The dwarf wheat can be planted at a shallower level than the deshi: four to six centimetres is suggested in the package of practices, but it needs to be able to penetrate the surface soil with its roots easily. The life cycle of the plant is short, at the most five months, and resistance from the soil is likely to inhibit its development. It is therefore necessary to have the top 20 cm. of soil well broken down, preferably by disc harrow, for the high yielding varieties. The arguments that roots need to penetrate the soil to greater depths to make their catchment area for plant nutrients as large as possible, is without much significance, as the plants can obtain all their nourishment from fertilizers which are to be found in the surface layers.

The deshi varieties of wheat are tall and thin strawed, so they require greater anchorage than the new wheat, and hence do not need such a well broken soil surface. As long as the clods of earth on the surface are large, the more likely the deshi wheat is to survive the effects of strong winds and rain, as the weight of the unbroken surface material affords the plants considerable protection. Many farmers preferred not to disc harrow their fields before sowing deshi, as the large clods of earth which would be broken by the disc harrow still remained in tact to protect the deshi wheat.

Number of times the land was ploughed.

Each farmer was asked how many times he ploughed his land before sowing early wheat, late wheat and deshi. Early wheat and deshi provide the best comparison of technique at this juncture. Unfortunately no differentiation was made between harrowing and ploughing with the conventional wooden ploughs. 68.00 per cent of the farmers ploughed for deshi the same number of times as for the new high yielding varieties. The answers of the remaining 32 per cent were compared by the Wilcoxon Matched Pairs Signed Ranks test as this assessed both the magnitude and the direction of the difference, and also assumed that the sample data were not independent of each other, but were paired (16). This test ignores values where change does not occur, and as in a case such as this, it could be of importance. The results of the test showed that the remaining 32 per cent of the farmers ploughed their fields a significantly greater number of times for new wheat than for deshi. The result was significant at the 1.0 per cent level of probability ($Z = 2.42$). Both the fields to be sown with new wheat and the fields to be sown with deshi were ploughed on average between eight and nine times. This was far higher than was really necessary for either type of wheat, but the farmers claimed that a greater number of ploughings put less strain on their draught animals than ploughing the solid ground adequately a few times.

It would have been of value to divide the farmers into groups according to their caste, village, farm size, education level, year of instruction and source of irrigation, to see whether these variables did have any effect on the dependent variable, the method of land preparation. This was not feasible

because the number of farmers within each group who showed a difference in approach to both new and old wheat was insignificant in comparison with the number of farmers whose approach was the same. We saw above that only 32 per cent of farmers approached this aspect of wheat cultivation differently for 'deshi' and for the 'new' varieties.

The depth to which the land was ploughed.

Each farmer was asked how deep he ploughed his fields for deshi and for the new varieties of wheat. In almost every case, the seed is sown through a dibbler, which is a tube which is attached to the plough, and so the depth of ploughing should be related to the depth at which the seed is sown. Just under two thirds of the sample farmers sowed their new and deshi wheat at similar depths of about 12cm. to 15cm. This is far deeper than 4cm. to 5cm., the depth at which the new wheat should be sown (17). Sowing to greater depths can have an adverse effect on plant development. Of the remaining farmers, that is, those who sow deshi at a different depth from new varieties, the Wilcoxon test again showed that there was a strong tendency for the farmers to sow their deshi wheat 2.5 cm. to 5 cm. deeper than their new seeds, but the result was not quite significant at the 95 per cent level of probability, ($Z = 1.85$), and so the possibility of this being a chance result is quite high. Some of the farmers were asked if and why they should sow deshi at a deeper level; the majority knew that deshi should be sown deeper than the dwarf wheat seed, even though they felt that in practice it was not an important consideration.

Methods used for ploughing.

The final section connected with land preparation is concerned with the methods used for ploughing the land. There was no significant difference in the method of approach to farming land for new wheat and for deshi. Only one out of 196 sample farmers used a mechanical plough. This was the farmer who cultivated the largest area of 32.38 hectares. Every other farmer used the traditional wooden plough as his main implement. On several occasions the farmers were asked why they did not use tractors for ploughing when they were available from the local Block Development Office. It was impractical, they always argued, to use mechanical farm implements because they had both the draught animals and frequently low cost labour resources. Tractors could be hired from the Block, but everyone wanted a machine at the same time. Even though the machinery was rent free, the operator had to be paid by the farmer and so did the fuel costs. The family usually constituted the larger part of the labour force, and if farm bullocks were also available, it seemed unreasonable to the majority of farmers to go to the trouble of hiring a tractor.

Labour saving devices were not the main object of the exercise. Labour was under-employed, and even though ploughing with bullocks took at least twice the time that a tractor and plough would take, because of the unavailability of the tractor and problems in organising the availability, the ploughing could be done at the farmer's convenience and need not be affected by any other factors. In short, the cultivators could see no reason for making farming less labour intensive. They were prepared as a rule, to modify traditional farming techniques if it meant higher returns, but they

felt that returns would be no lower if the techniques were implemented by manual labour rather than machinery. The other argument that farmers put forward against the use of machinery was its unreliability. If a tractor broke down, the length of time it would take to replace or repair the part was enough to ruin the farmer's organisation and routine, and so more often than not, the tractor was not a time saving device. The cultivators were prepared to agree that a tractor had potential use on their farms, but at present they felt that the traditional equipment was far more economic in terms of time, money and more especially, effort.

There seemed to be little difference therefore, between the farmers' approach to preparation of their land for either the new dwarf varieties or for deshi. At the same time for the most part, the techniques used did not fall far short of the requirements of the package of practices. This was not because land preparation methods are so similar for the new varieties and deshi. The farmers seemed to be doing more for the deshi wheat than it required, according to the list of requirements for deshi provided with the details of the package of practices by the Principal of Bulandshahr's Agricultural College. Four or five ploughings instead of six for deshi should be adequate according to the theoretical information. 10cm. to 12cm. instead of the mean 12cm. to 15cm. would also be an adequate depth.

The approaches to farming both the new varieties and deshi wheat were not as dissimilar as was anticipated at the beginning of the study. Some cultivators were beginning to understand the

value of a scientific approach to farming and so attempted to use similar techniques for the indigenous varieties as for the new wheat. Although this was not a recommended policy, one was aware of the general incentive to increase the output per unit area of deshi varieties especially as they had become relatively valuable since their widespread replacement by the new dwarf wheats, and the growing awareness that the deshi varieties made a more acceptable chapati.

6.2

Seed preparation.

Farmers sowing the new high yielding varieties are urged, by the package of practices, to change their seed at least once every four years. This is new to the cultivator, as deshi wheat seed used not to be renewed regularly and was often kept for longer than a decade. Fig.6.1. is a frequency table which compares the dates when farmers obtained their main new variety of seed and their deshi seed. It refers to only those farmers sowing both new and deshi wheat, and it is apparent (Fig.6.1) that few of the farmers growing new wheat have had their new variety longer than the advised time, while the deshi seeds have been used by the farmers for a greater number of years. The new high yielding varieties have been available for a relatively short time, so the range of years could not be so large, but there does seem to be a strong tendency for these varieties to be renewed more frequently than the deshi wheat. The proportion of farmers who obtained their main new variety from 1968-69 to 1971-72, four seasons, is 50.00 per cent, while the equivalent statistics for deshi wheat is 21.57 per cent.

The comparison by the Kolmogorov-Smirnov test between the frequency curves of the year deshi and the main variety of the new wheat seed was obtained (Fig.6.1) was not statistically significant, but when the proportion of farmers who changed their new wheat seed either during or after 1969, is compared by the chi square test (18) with those who changed their deshi wheat during the same period, the result is highly significant at the one per cent level of probability (chi square = 16.200).

These results do illustrate that new wheat growers are to some extent following the patterns set by the package of practices, and so are changing certain traditional techniques when they begin to sow their new high yielding varieties of wheat.

Table showing the years when farmers who grow both new and deshi wheat obtained their seed.

| <u>Year.</u> | <u>Year new wheat seed obtained</u> | <u>Year deshi wheat seed obtained.</u> |
|--------------|-------------------------------------|--|
| <u>1940</u> | | 1.96 per cent |
| 1960 | | 1.96 |
| 1961 | | 1.96 |
| 1962 | | 5.88 |
| 1963 | | <u>19.61</u> |
| 1964 | | 5.88 |
| 1965 | 1.96 | 9.80 |
| 1966 | 3.92 | 5.88 |
| 1967 | <u>27.45</u> | 15.69 |
| 1968 | <u>15.69</u> | 7.84 |
| 1969 | 7.84 | 5.88 |
| 1970 | 23.53 | 7.84 |
| 1971 | 17.65 | 1.96 |
| 1972 | 1.96 | 5.88 |

50.98

Source: Field work for the Wheat Study - March 1972.

Fig.6.1.

Table showing the year in which farmers obtained seed
for all their new high yielding varieties.

| <u>Year</u> | <u>Variety in order of area sown</u> | | | | | |
|-------------|--------------------------------------|---------------|--------------|---------------|--------------|--------------|
| | <u>first</u> | <u>second</u> | <u>third</u> | <u>fourth</u> | <u>fifth</u> | <u>sixth</u> |
| 1966 | 5.70 | 4.17 | 6.13 | | | |
| 1967 | 16.06 | 9.72 | 5.03 | | | |
| 1968 | 10.88 | 11.11 | 3.03 | 11.54 | | |
| 1969 | 15.03 | 18.75 | 21.21 | 3.85 | 20.00 | |
| 1970 | <u>27.80</u> | 21.53 | 21.21 | 23.08 | 30.00 | |
| 1971 | 17.67 | <u>26.39</u> | 19.70 | 23.08 | 10.00 | 33.33 |
| 1972 | 6.22 | 15.29 | <u>25.76</u> | <u>38.46</u> | <u>40.00</u> | <u>66.67</u> |

Source: Field work for the Wheat Study - March 1972.

Fig.6.2

Farmers who obtained their new wheat seed
before and after 1969.

| <u>Year</u> | <u>Variety numbers.</u> | | | | | |
|------------------|-------------------------|-------|-------|-------|--------|--------|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| <u>pre 1969</u> | 32.81 | 18.06 | 12.12 | 11.54 | ----- | ----- |
| <u>post 1969</u> | 67.19 | 81.94 | 87.88 | 88.46 | 100.00 | 100.00 |

Source: Field work for the Wheat Study - March 1972.

Fig.6.3.

A frequency table was constructed for all the farmers growing new high yielding varieties (Fig.6.2). In this case nearly 67 per cent of the farmers had obtained the seed for their main variety between 1969 and 1972, though the difference between this and nearly 51 per cent for the new wheat and deshi growers alone (Fig.6.1) was far from statistically significant. The data were then analysed at a more detailed scale, the farmers were sub-divided on the basis of their village identity, caste, education, size of the area farmed and source of irrigation.. In no case were variations in the data explained by these variables when tested by the Kruskal-Wallis analysis of variance test. Information about changing the seed frequently for the new high yielding varieties seemed to be fairly well diffused among the sample farmers (Fig.6.2)

Farmers might follow the recommendations of the package of practices for their main varieties, but the question of whether the farmers were so careful about their less important varieties was next to be examined. 75 per cent of the farmers grew more than one variety, and the frequency table (Fig.6.2) confirms

the idea that when farmers adopt a new variety, they sow a small area of it initially for trial purposes and for seed development. Rather than the less important varieties being older, they were newer. The largest number of farmers obtained seed for their second variety in 1971, and for any other varieties covering a lesser area in 1972 (Fig.6.2). Fig.6.3 compares the proportion of farmers who obtained their seed either before 1969 or during and after that particular year. 1969 has been selected because it was four years before the field work was carried out, and so the 'limit' set by the package of practices for seeds which had been developed on the same farm since then, had been reached.

The less important varieties of wheat may have been obtained after the main variety, but the Kruskal-Wallis test did not show these differences in age to be statistically significant. However, when the proportion of farmers who have either newly acquired or have renewed their seed during or after 1969 is compared by the chi square test with those who have not done so, the difference is highly significant at the one per cent level of probability (chi square = 25.020). This result shows that farmers are generally following the package of practices and are replacing their new varieties within the four year limit.

Treatment of the seed before sowing.

One of the greatest problems involved in new dwarf wheat farming is the possibility of attack from as yet unknown pests, against which the indigenous varieties had developed an immunity. In 1968 large areas of wheat were destroyed by pest which

attacked the seed (19). Since then farmers have been encouraged to pre-treat their seed and to use pesticide on the plants themselves. The seed should be soaked in a four per cent solution of a chemical called Agrosan GN or Coresan; 2.5 gm. of chemical per kg. of seed. Both of these have a mercuric base and this ensures that the seed is not destroyed before it has a chance to germinate. All seed sold by the National Seeds Corporation has always been treated, but the same is not always true of seed sold by private agencies. As nearly 41 per cent of the farmers obtained their seed from private merchants, friends and neighbours, and an insignificant proportion of the cultivators take the trouble to pre-treat their seed with pesticide; much of the seed used has not been properly prepared.

Deshi wheat seed has never been treated and so farmers see little reason for varying this part of their farming technique, as there is no certainty that yields will be low if pesticide is not used. Under two per cent of the farmers had originally obtained their seed from the National Seeds Corporation, and though the seed had been protected when it was first sown, the treatment has to be renewed each season. 94 per cent of the 196 farmers had sown untreated seed. This was one aspect of farming where cultivators seemed to be adhering to tradition, rather than modernising their approach to farming.

The seed rate.

The seed rate for the new high yielding varieties of early wheat should be higher than for deshi. Intensification of the seed rate is another method of increasing the yield per unit area.

Returns from the new high yielding varieties can only be maintained at high levels however, if inputs of fertilizer and water are adequate. Deshi cannot tolerate such high inputs of fertilizer and although the plants respond easily, the tall thin stalks often over 130 cm. in height, cannot support heavy heads of wheat. The plants lodge and much of the crop is lost. The nutrient content of the soil in deshi wheat fields is usually significantly lower than in dwarf wheat fields through lighter applications of fertilizer, if any is used at all. A high seed rate in deshi wheat fields is not worth while as growth and development of the plants will be inhibited by nutrient deficiency. This is the theoretical reason for a lower seed rate in deshi wheat fields. In practice it was found that the mean seed rate for deshi was 6.78 kg. per bigha (83.73 kg. per hectare) and 7.89 kg. per bigha (97.44 kg. per hectare) for the new wheat. In absolute terms the differing seed rate may not be very great, but when the frequency tables for the seed rate are compared by the Kolmogorov-Smirnov test, the data showed that the curves are significantly different at the one per cent level of probability ($D = 0.36$). This means less deshi seed than new high yielding varieties (Fig.6.4) of seed is sown per unit area within the areal limits of the Wheat Study.

Both early and late varieties of new wheat are available to the cultivator; the concept of a late wheat crop with a short maturation period was a new one as, indigenous varieties of wheat took longer to mature and so, the time of sowing was limited to a specific period. The cultivators of the study area were aware of the existence of the new late varieties, but they

lacked the enthusiasm to sow a second or late wheat crop. Nearly 38 per cent of the farmers sowed both early and late wheat, and no reason other than personal preference was apparent as to why these particular farmers chose to sow late varieties. They were not of a particular caste, they did not own the largest farms, they were not educated to the same level nor did they come from one village. The late variety should be sown during the last fortnight of November and will have a shorter maturation period. The sizes of the individual grains are usually smaller and less well rounded than the early wheat grains and than the slow maturing deshi wheat. Late wheat is much lighter than the early sown crop and in order to harvest grain similar in quantity to the early varieties, the seed rate needs to be higher. The mean seed rate of the late wheat in the study area is about 114.57 kg. per hectare in comparison with the recommended seed rate of 30 to 35 kg. for early and late new varieties and, according to the Principal of the Agricultural College, Bulandshahr, 20-25 kg. for deshi. The early dwarf wheat is closest in its physical requirements to the indigenous varieties, and apart from sowing dates, the seed rate and the length of the maturation period, the approaches to farming both the early and the late varieties of the new high yielding wheat, are similar. Details on the method of growing the late varieties has therefore been omitted.

As the difference in the seed rate is so important in the farming of early and late varieties, and as the concept of the late wheat crop is completely new to the Indian farmer, the seed rates of the early and late varieties were compared by the

Wilcoxon Matched Pairs Signed Ranks test. Only 72 of the total sample of farmers sowed a late crop of wheat, but the seed rate for the late wheat was significantly higher than for the early wheat, so indicating that the farmers were prepared to change their farming approach.

Table comparing the seed rates used for the new high yielding varieties and for the indigenous wheat.

| <u>Seed rate kg/bigha</u> | <u>equivalent in kg/hectares</u> | <u>percentage new high yielding wheat.</u> | <u>percentage indigenous varieties of wheat</u> |
|-------------------------------|--------------------------------------|--|---|
| 6 | 74.10 | 8.51 | <u>44.68</u> |
| 7 | 86.45 | 29.79 | 36.17 |
| 8 | 98.80 | <u>38.30</u> | 17.02 |
| 9 | 111.15 | 10.64 | 0.00 |
| 10 | 123.50 | 12.77 | 2.13 |

Source: Field work for the Wheat Study - March 1972.

Fig.6.4

The mean seed rate for the early new varieties sown by the farmers was 96.58 kg. per hectare and for the late varieties, the comparable statistic was 114.57 kg. per hectare. The seed rates were absurdly high in comparison with the theoretical requirements, and when questioned about the figures, the farmers confirmed that such seed rates were essential if 'reasonable' yields were to be obtained. The package of practices recommends a seed rate of about 25 to 35 kg. per hectare for the double gene varieties. There may be a slight amount of variation - to within 20 per cent - on account of the varietal

differences (20), but the difference between the theoretical seed rate and that of the farmers was surprising when the majority of the farmers sow the double gene varieties of Sonalika and Kalyansona as their main varieties.

The conclusion to this section is difficult. Deshi wheat seed is being sown at a rate far higher than that indicated to be necessary by the Principal of the Agricultural College at Bulandshahr. A certain increase in the seed rate is understandable as many deshi growers are now applying some fertilizer to the 'old' wheat, but the seed rates recorded in the Wheat Study area do seem inexplicably high. Yields can be increased if the seed rate is raised and some fertilizer is applied. There is, however, a fine line between success and total failure when such techniques are practised on the indigenous varieties. The high seed rates for the early and late varieties of new wheat are also perplexing. These well exceed the requirements of the package of practices and all that can be said is that the farmers do seem to understand that the seed rate for the late varieties does need to be higher because of the relatively short maturation period which results in smaller, lighter grains of wheat.

The seed rates did vary, though not a great deal and the 'independent' variables helped to explain little of the variation that occurred in any aspect of the dependent variables. The most interesting point emerging from this section is the uniformly high input of seed. It is far higher than that recommended in the package of practices and is frequently two to three times as much as is necessary. If this information was false, it would

have been a great coincidence that 196 farmers from six villages, which were not in close communication, could have reproduced the same untruth. It is felt that there must be a reason for such a major divergence from the package of practices, from which farmers have not diverged a great deal on any other aspect.

The time of sowing wheat seed.

The period for sowing the new high yielding varieties is limited. According to the package of practices, the first two weeks of November are the most suitable time for sowing the new wheat and the next two weeks are the optimal sowing period for the late wheat. For every week that the farmer is late with his sowing, his yield will be reduced¹ (21). Deshi has always been sown from mid-October to mid-November, a slightly longer period, but the short life cycle of the new high yielding varieties, means that the seed cannot be sown too early as the wheat will not ripen properly if temperatures do not rise early in the year, and if sown too late, the crop matures too rapidly in the excessive heat, so producing shrivelled grains.

Fig.6.5 shows that the farmers sowing both new wheat and deshi, sowed the new wheat mainly in the first two weeks of November while most of the deshi was sown a week earlier.

1. According to the package of practices for the Punjab "there is a gradual decline in yield if sowings are delayed beyond the optimum period. A delay of one week in sowing reduces the yield by 150-160 kg./acre" (37.05-39.52 quintals per hectare). This must be an error as the loss through the delay in sowing time would be greater than the total amount harvested by many of the farmers. 15.0-16.0 kg./acre would be a more likely figure as this would reduce the yield by approximately ten per cent.

Source: Singh, K.P. Package Practices for Rabi Crops of Punjab, 1971-72. Ludhiana 1972, p.4.

Only five farmers sowed deshi in the fortnight that followed. The greater part of the deshi wheat had been sown during the last week of October and the first week of November, but the number of weeks over which farmers sowed it, was quite considerable. The earlier sowing of deshi is to be expected because it has a longer maturation period than the new high yielding varieties. Farmers also tend to sow it earlier to capitalise on the last of the monsoon rains. They economise on one irrigation by doing this, but this policy is not successful in the case of early wheat. The compact nature of the table shows that the farmers are sowing their early wheat at more or less the correct time. The null hypothesis which, in this case, would claim that the weeks of sowing of new early wheat and deshi are not significantly different, cannot be accepted. In order to obtain an index of comparison, the Kolmogorov-Smirnov test was used and this showed that the patterns of when the wheat was sown, were significantly different at the one per cent level ($D = 0.35$).

When the sowing time of early wheat for all the farmers growing the new high yielding varieties was examined, the pattern was little different from Figs. 6.6. and 6.7. Again, the majority, 84.00 per cent, of the farmers sowed their new wheat within the first fortnight of November and so complied with the requirements of the package of practices. This further ensures that the null hypothesis claiming that the farmers do not follow the package of practices, cannot be accepted (Chapter 2.p. 59). Field observation showed that not all the farmers sow all their wheat at one time. In fact, 34.00 per cent of the farmers sowing early wheat spread

their sowing period over more than one week.

Table showing the weeks when most of the new wheat
and indigenous varieties were sown by farmers
growing both these types of wheat.

| <u>Week</u> | <u>Early new varieties of wheat</u> | <u>Indigenous varieties of wheat.</u> | |
|-------------|---|---|---------------------|
| October 1 | | 2.04 | per cent farmers |
| 2 | | 4.08 | |
| 3 | | 12.24 | |
| 4 | 2.04 | <u>38.78</u> | |
| November 1 | <u>46.94</u> | <u>28.57</u> | |
| 2 | <u>44.90</u> | 8.51 | |
| 3 | 6.12 | 4.08 | |
| 4 | 2.04 | | |
| December 1 | | | |
| 2 | | | |
| 3 | | 2.04 | |
| 4 | | | |

Source: Field work for the Wheat Study - March 1972.

Fig.6.5

Fig.6.6 also shows when the remainder of the early wheat is sown. Whereas the first and second weeks of November were the most popular for sowing the early varieties, the second and third weeks of November saw most of the remaining early wheat planted. It was interesting that some farmers sowed the smaller proportion of their wheat earlier rather than later. They said the chances of obtaining larger grains were better if it was sown earlier(Fig.6.6). Owing to this practice, the period over which the smaller quantity

of wheat was sown, was much longer than the first sowing period. It extended from the third week in September until the first week of December. Approximately 30.00 per cent of the remaining early wheat was sown during the first two weeks of November (Fig.6.6), while the greater part was sown later.

Table showing the weeks when the entire sample of farmers sowed the bulk and the remainder of their early new high yielding varieties of wheat.

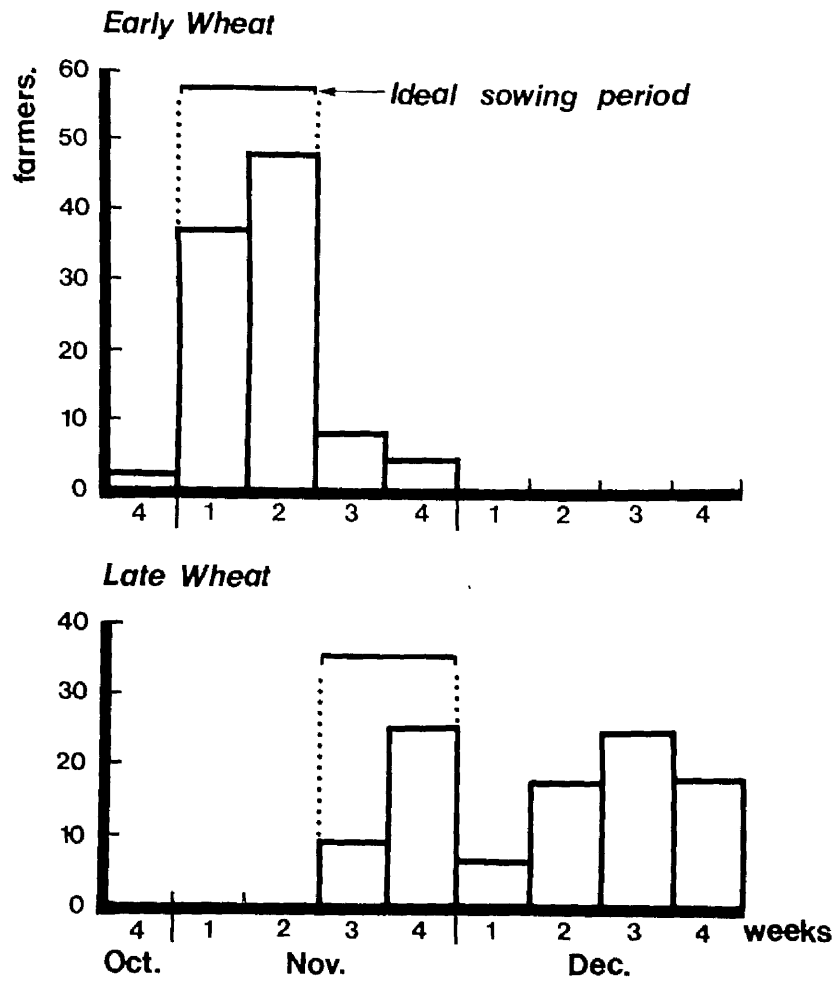
| Week | Proportion of farmers sowing bulk of early new wheat. | Proportion of farmers sowing remainder of early new wheat. |
|------------|---|--|
| October 1 | | 11.27 |
| 2 | | 1.41 |
| 3 | | |
| 4 | 2.09 | |
| November 1 | <u>37.17</u> | 4.25 |
| 2 | <u>48.17</u> | <u>25.35</u> |
| 3 | 8.38 | <u>36.62</u> |
| 4 | 4.19 | 16.90 |
| December 1 | | 4.23 |
| 2 | | |

Source: Field work for the Wheat Study - March 1972.

Fig.6.6

In this event, the farmers were not following the package of practices, and so the null hypothesis that farming traditions and techniques were not being modified, could not be rejected. It must be said that between the first and the third weeks of November, 67.13 per cent of the wheat had been sown, so, if returns reduced by five per cent for every week that the wheat

WEEKS WHEN THE MAJOR PART OF EARLY AND LATE
'NEW' WHEAT WERE SOWN IN RABI 1971-72.



Source: Field work for the Wheat Study - March 1972.

Fig. 6.7

was sown late, less than one third would have shown a loss of more than five per cent. When compared with deshi, it was apparent that only 11.00 per cent of deshi farmers took more than one week to sow their deshi. This could have been because of the relatively small quantity that is sown, or, because it needs to be planted as soon as possible because of its longer life cycle.

The data were examined at the more detailed scale of village, caste, area farmed, education level, the year of instruction in new farming techniques and the number of irrigation sources. There appeared to be no change in the pattern at any level. The greatest number of farmers always sowed their wheat within the first two weeks of November, as the package of practices suggested they should, and most of the remaining wheat was sown in the second and third weeks of November, usually the week after the bulk was sown.

At every scale the null hypothesis, that farmers were not keeping to the package of practices, could not be accepted, as far as most of the users of early wheat were concerned.

Late wheat.

According to the Principal of the Agricultural College, Bulandshahr, the package of practices recommends that late wheat is sown during the last two weeks in November, and at the very latest the first week in December. Sowing after this date causes yields to fall markedly. The sowing period is as restricted for late wheat as it is for the early varieties. The farmers might have been sowing their early wheat at the

appropriate time but the same compact showing pattern is not present for the late wheat (Fig.6.7). The sowing period extends over a much greater length of time. Sowing of late wheat commenced in the third week of November, and as suggested by the package of practices, ended in the last week of December, four weeks later. Less than one third of the farmers sowed their late wheat in the last two weeks of November.

Table showing the weeks when the bulk and the remainder of the late high yielding varieties of wheat were sown.

| <u>Week</u> | <u>Proportion of farmers sowing bulk of late new wheat.</u> | <u>Proportion of farmers sowing remainder of late new wheat.</u> |
|-------------|---|--|
| November 1 | | |
| 2 | | |
| 3 | 9.41 | |
| 4 | 24.71 | 14.29 |
| December 1 | 5.88 | |
| 2 | 17.65 | |
| 3 | <u>24.71</u> | <u>42.86</u> |
| 4 | 17.65 | 35.71 |
| January 1 | | 7.14 |

Source: Field work for the Wheat Study - March 1972.

Fig.6.8

Curiously, the frequency diagram of late wheat sowing patterns has two peaks to it (Fig.6.7). There seemed to be two definite periods when late wheat was sown. The first peak in the fourth week of November coincides with the package of practices, and the

second peak in the third week of December.

The farmers were aware that they should sow late wheat during the last two weeks of November, but when they grew other wheat as well, many found it preferable to sow their late wheat even later, as it staggered the harvest, even at the expense of obtaining a reduced yield.

Only 14 of the 72 farmers growing late wheat extended their sowing period over more than one week. There is more of a rush to sow late wheat as, the later it is sown, the higher the losses at harvest time, as seeds which mature rapidly are often shrivelled and weigh less than the well developed early varieties.

Other than for reasons of personal preference, there appeared to be no cause for these 14 farmers to extend their late wheat sowing period. Statistical tests also showed there to be no significant difference in the proportion of late wheat growers of different caste, education level, farm size or village. Neither was there any marked relationship between late wheat and deshi growers. It all seemed a matter of personal choice. Farmers appeared to treat late wheat as 'another variety' rather than realize its potential value in the cropping pattern.

Fig.6.8 also shows the weeks when the remainder of the late wheat was sown. During the last two weeks of December, 78.57 per cent of this crop was sown. Again, with regard to the remainder of the late wheat, the null hypothesis cannot be rejected. The farmers were sowing their seed far later than they should have

been to obtain satisfactory, if not optimal returns.

We have established that the patterns of the package of practices have been followed fairly closely by early wheat growers. Late wheat raising, however, is a new concept and the physical requirements of the late varieties are far removed from deshi. As its life cycle is so much shorter, frequently as much as four weeks shorter, the work of the farmer cannot continue at a leisurely pace if he intends farming the crop properly. Confusion seemed to exist about the sowing dates for late wheat, and this is clear from Fig.6.8. Unfortunately, the sowing date is probably one of the most crucial factors in the life cycle of late wheat. The potential of the late varieties has not been fully realised as yet, as most farmers failed to appreciate that it could be grown as a second rabi crop after a quick crop of pulses or potatoes, and not as a mere after thought for the rabi (22).

Late wheat could enable a farmer to increase his cropping scheme for at least two to three crops in an agricultural year. If the concept of late wheat growing is not extended beyond the farmer who does not sow all his early wheat in time, then it will never catch the imagination of the cultivator and work its way into the rotation system. If it is used, not as a second rabi crop, the relatively high inputs of seed, water and fertilizer must make it an uneconomic crop to sow. Extension services appear to have been highly successful in spreading information about the requirements of the early wheat. The added value that a late rabi crop could have to the cropping system, did not seem

to have reached the farmer yet, or, if it had done so, then the opportunities of the new, late varieties were not fully appreciated.

6.3

Fertilizer.

One of the major differences between the new high yielding varieties and deshi wheat is that the farmer requires large doses of chemical fertilizer, more than double that which the deshi can tolerate. The dwarf nature of the new hybrid seeds enable them to bear large and heavy heads of grain. The plants are, on average, one metre high and the heads of wheat are about 10 cm. long and each weighs about 0.80 to 1.00 gramme. Details of the physical characteristics of the plant will be considered in chapter 7, but they are useful here as a comparison with deshi wheat which frequently stands over 1.30 metres in height and bears ears about 6 - 7 cm. in length. The weight of these is usually just about half the weight of the head from a dwarf plant. Deshi responds well to fertilizer, but the thin stalks would be damaged very easily if the ears increase in size significantly.

The soils of the study area are almost devoid of organic material. Soil fauna are rarely found and the texture of the soil is sandy and dry (23). Without added chemical fertilizers and water, the new high yielding varieties would prove worthless in this environment, and the indigenous varieties would be preferable.

The purpose of this section is to see if the farmers are applying fertilizer to their new wheat. If they are, they must have changed their approach from the traditional one and, if fertilizer is being used, is it being administered in timely fashion and in adequate quantities.

The usual method of discovering whether farmers had changed their farming techniques, was once more used. The inputs of fertilizer to deshi wheat were compared with the inputs of fertilizer to the new high yielding varieties. The Wilcoxon Matched Pairs Signed Ranks test was again used, and the result was a Z value of 4.72 which was highly significant at the 0.1 per cent level of probability, showing that the new varieties received more fertilizer than the deshi wheat. In general, the farmers clearly appreciated the importance and the necessity of chemical fertilizers to the new high yielding varieties. Though the mean values cannot be compared statistically, it is interesting that the mean quantity of fertilizer applied by these farmers to the new wheat is 164.72 quintals per hectare (13.29 kg. per bigha), and 75.87 quintals per hectare (6.14 kg. per bigha) to their deshi wheat. This matches the recommendation of the package of practices that deshi wheat should receive about half the fertilizer applied to the new wheat, although as we shall see, the 164.72 quintals per hectare level for the new wheat is less than that recommended in the package.

The chemical fertilizers available to the farmer are numerous. Farmers were asked what quantity of each type of fertilizer they had used in rabi 1971-72. Urea was by far the most common and was used by 86.00 per cent of the farmers. 43.00 per cent used the mixture known as 'NPK', and 26.00 per cent used the mixture 'CAN' - calcium ammonium nitrate. These were the three most popular varieties which supplied the soil with all the essential nutrients for wheat farming. All three

supply nitrogen, NPK supplies phosphates and potassic compounds and, in addition CAN contains calcic compounds. Nearly 9 per cent of the farmers used all three types of fertilizer.

Urea is the most commonly used because it is heavily subsidised by government. In rabi 1971-72 the cost of urea was Rs.95-00 per quintal as compared with Rs.90-00 and Rs.55-00 for equivalent weights of 'NPK' and 'CAN'. 76.00 per cent of the farmers used urea as their main fertilizer, though quantity is not the best method of assessing the importance of fertilizers. One aspect of the field work was concerned with the adequacy of the fertilizer being used. This is very difficult to assess from questionnaire material, because every area has slightly different soil conditions and hence chemical requirements. In addition to this, the quantity of one kind of fertilizer which is needed differs from the next, according to its constituents and concentration. As farmers frequently use more than one type, it is a problem to discover whether or not they are using enough. The most common reason for low yields is attributed to the lack of material inputs, particularly of fertilizer (24). So far, the farmers have followed the recommendations of the package of practices fairly closely. This section aims to see whether they are using sufficient fertilizer or not.

In order to do this, the results of the analysis of soil samples taken in the area were taken into account. Soil samples had been collected from each of the six villages at the time of enumeration, and details of the method of their collection are included in Appendix 2.2. The soil samples were analysed for

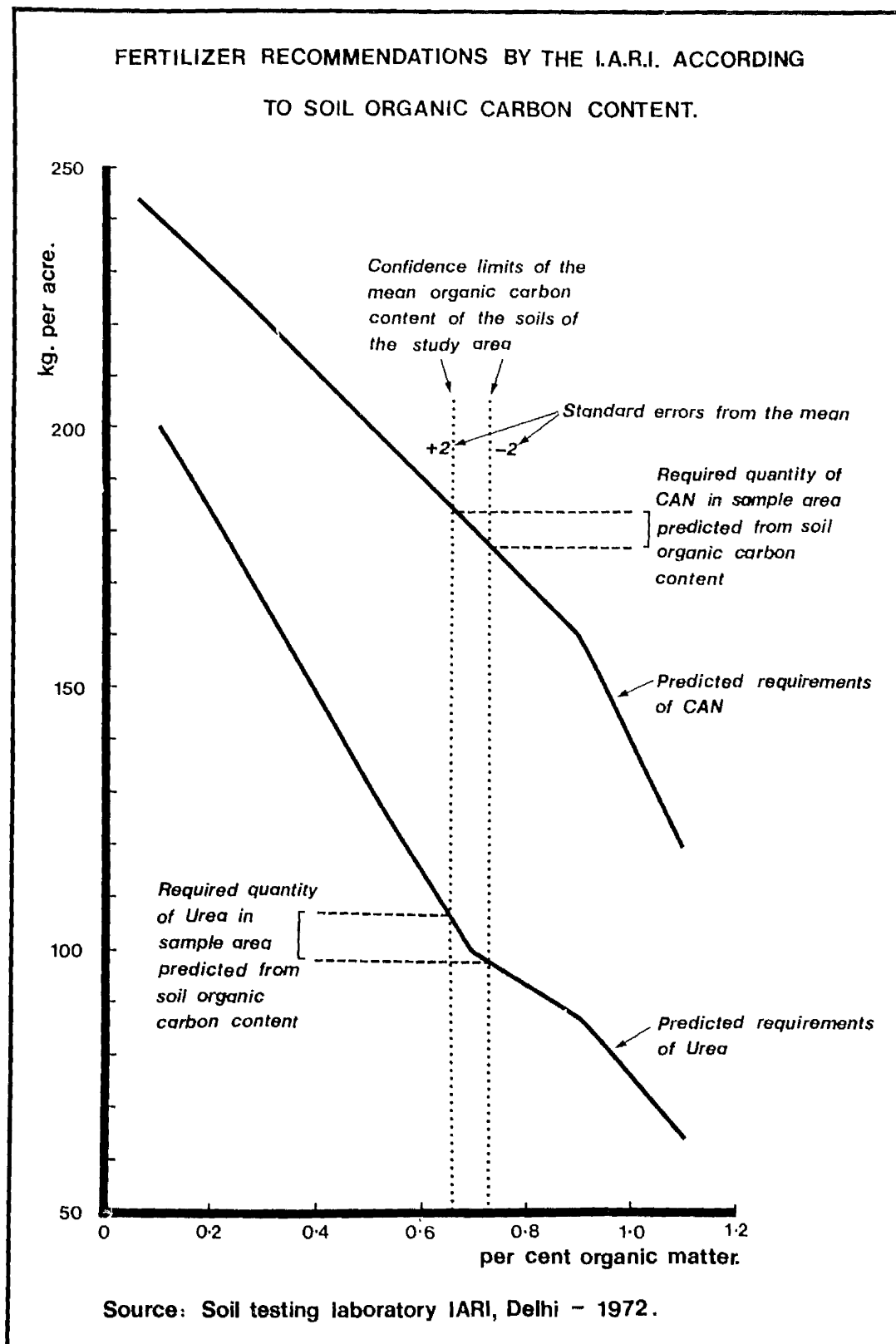


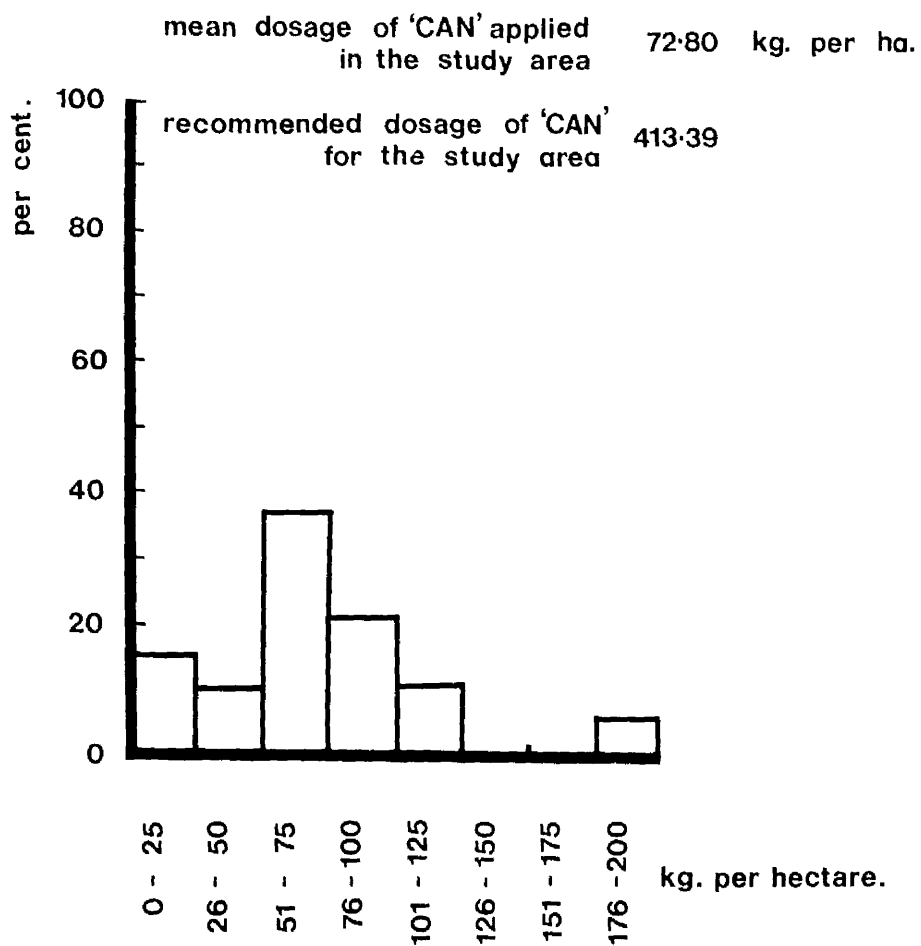
Fig. 6.9

selected physical and chemical constituents at the Indian Agricultural Research Institute in Delhi.

Among the variables which were examined was the organic carbon content of the soil. From the estimation of the organic carbon content of the soil, by ignition of the soil in a muffle furnace, the quantity of urea, CAN and other nitrogenous fertilizers necessary for successful wheat farming can be estimated. Fig.6.9 shows the relationship between the proportion of organic matter in the soil and the quantity of urea and CAN that should be applied for the new high yielding varieties of wheat. These theoretical assessments are based on work carried out at the Indian Agricultural Research Institute in Delhi. The range of organic carbon content in the soils samples varied little and the Kruskal-Wallis non-parametric analysis of variance test (25), confirmed that there was no significant difference in the organic content of the soil in any of the six sample villages. The mean value of the organic content in the soil was calculated, (mean = 0.69 per cent), and so was the standard error to plus or minus two confidence limits (0.65 - 0.73 per cent). The result of this was that 95 per cent of the soil samples fell within this range. The urea and CAN requirements for both the upper and lower confidence limits were then read off, (Fig.6.9). As the range was so small, it was thought safe to assess the adequacy of urea and CAN inputs on the basis of the lower confidence limit. In the case of urea it was 97.50 kg. per acre (19.40 kg. per bigha) (239.40 kg. per hectare), and CAN users were required to apply a minimum of 176.40 kg. per acre (33.50 kg. per bigha) (415.39 kg. per hectare) to their new high yielding varieties in order to comply with the theoretical

DIAGRAM SHOWING THE INADEQUACY OF 'CAN' INPUTS.

('CAN' = calcium ammonium nitrate)



Source: Field work for the Wheat Study - March 1972.

Fig. 6.10

requirements of the package of practices. The data were provided in acres and so it was more suitable to convert the statistics to kg. per hectare after the results had been obtained.

Every farmer can send a sample of his own soil to a government soil department for analysis, and so discover the correct fertilizer requirements for his particular fields. This service is not used very often, as farmers still seem to prefer to assess their own fertilizer requirements. The mean quantity of urea applied by all the farmers who used this as their main type of fertilizer, was 13.67 kg. per bigha (168.79 kg. per hectare). This was 70.50 per cent of the quantity necessary for the area, which, although low is not as low as is often indicated. Work by Ladejinsky (1969) (26) for instance, shows that farmers in the Punjab, used far less than the required quantity of fertilizer on their wheat fields. In the Wheat Study area, however, only 28 per cent of the sample farmers used sufficient or more than enough fertilizer, while 72 per cent fell below this line.

The predicted requirements of CAN for the soil of the sample area was 33.50 kg. per bigha (413.39 kg. per hectare). Not one of the farmers using CAN as his main fertilizer applied an adequate quantity. The mean value applied was 5.84 kg. per bigha (72.80 kg. per hectare), that is to say, 17.61 per cent of the required minimum. Fig.6.10 shows how inadequate were the inputs of CAN.

Nearly 43 per cent of the farmers use NPK, and in only ten cases was it their main fertilizer. This is not surprising as

the relative quantity of NPK required per unit area is far less than urea or CAN. It is even less easy to predict or generalise about the quantity of NPK that should be applied to the soil. The quantity of phosphatic and potassic fertilizers required are calculated on the basis of available phosphate and potassium compounds in the soil. These are not 'naturally' occurring in any significant quantity, but are directly related to the quantity of these fertilizers that have been applied in the past. Available phosphorous is calculated by Olsen's method (27), and available potassium from the nitrogen ammonium acetate method (28). No conclusions can be drawn nor predictions made about the phosphatic or potassic fertilizers in any of the fields that have not been sampled. Assessments of the adequacy of the inputs of these particular types can only be based on those fields which have been sampled.

The NPK group of fertilizers are a much more recent introduction to the farmer and it was significant that the largest proportion of cultivators using NPK occurred in caste group I among the Jats, Brahmins and Rajputs (Chi square = 8.92 significant at the 5 per cent level). Consequently nearly 53 per cent of the farmers using NPK farmed areas larger than the mean area. In comparison, an analysis of fertilizer used by farmers with holdings below 3.54 hectares, revealed that while only 36 per cent of these 'smaller' farmers used NPK, nearly 50 per cent used urea. The latter is far more popular among the 'smaller' farmers.

The frequency of farmers within each caste who were

applying adequate or less than adequate fertilizer were compared by the chi square test for 'K' samples (29), and a significant difference was obtained showing that the members of the higher caste groups I and II used sufficient fertilizer more frequently than did those farmers of caste group III, the Chamars, Muslims and Muslim Rajputs, (Chi square = 16.86 significant at one per cent Level). A further chi square test between groups I, the Jats, Brahmīns, Rajputs and II, the Gujars and Lodhas showed no significant difference in the frequencies of adequate and inadequate applications of fertilizer. Apart from variables which are linked directly with caste, no other independent variable, such as the village, or the year of instruction, explain any significant part of the variation in the proportion of fertilizer which should have been applied. For the most part, farmers applied at least half the fertilizer they should have used, and although it was often short of the quantity recommended by the package of practices, it was nearly always higher than the fertilizer used for the indigenous varieties, shown by the Wilcoxon test, ($Z = 4.72$ significant at 0.1 per cent level). These results show that even if farmers are not yet complying with all the demands of the new varieties, they have increased their use of fertilizer significantly since the introduction of the new high yielding wheat, so rejecting the part of the null hypothesis (Chapter 2.p. 59) which claims that no significant change has occurred.

6.4

Irrigation.

Sufficient water applied at the correct time in the plant life cycle is of the utmost importance in farming the new high yielding varieties of wheat, but data on the quantity of water applied to the new wheat were very difficult to obtain with any accuracy. Water was pumped from tube wells at different rates; irrigation was often interrupted by electricity cuts; there could be no method of the farmer knowing the quantity of water he drew from a well, and although such data could be estimated from a few detailed samples, it was felt that such generalisations would be of more theoretical than practical value, and consequently of little value to the Wheat Study. A compromise was made and the farmers were asked not, how much water they used, but, the number of irrigations they gave the plants during the rabi 1971-72, as the frequency of irrigation is no less critical a factor than the quantity of water that is supplied.

Grain yields depend on the number of effective tillers per unit area, the number of grains per ear and the individual grain weight. Tillering depends on the moisture and nutrients present in the soil, and success at the tillering stage is largely determined by the efficiency of the crown roots which develop just before the tillers. Adequate moisture must be available to the plant three weeks after sowing when the crown roots develop, and the first irrigation must be given to meet these needs. If it is too early, capillary movement of the soil moisture leads to a deposition of a crust of mineral salts on the surface which hinders the development of the crown

roots. This in turn limits their ability to transport moisture and nutrients efficiently to the tillers and so the development of the plant is retarded. The timing of the first irrigation is clearly of critical importance to the success of wheat.

The maximum number of tillers produced must be capable of bearing good ears, and this leads to the importance of late tillering irrigation. Ears which have infertile spikelets contribute nothing to the wheat yield, and so an irrigation is also essential at the flowering stage. As temperatures rise during the season, the ears of wheat develop, but unless the plants are also watered at the 'milk' or 'dough' stage, that is, while the grains are swelling, they will shrivel (30). These three irrigations to a depth of five centimetres are essential, but a more successful wheat crop is harvested with six waterings applied every 20 to 30 days.

The new varieties require far more water than the indigenous varieties. The package of practices advises that they are watered six times during their life cycle while the indigenous varieties need about three irrigations (31). The farmers who grow both the new high yielding varieties of wheat and the deshi varieties were asked how many applications of water were made to each of these types of wheat. Fig.6.11, compares the number of times the new wheat was watered with the number of waterings given to the deshi wheat.

A comparison of the number of irrigations to the new early varieties of wheat and to the indigenous varieties.

| <u>Number of irrigations</u> | <u>Early new wheat</u> | <u>Indigenous varieties.</u> |
|------------------------------|------------------------|------------------------------|
| 1 | | |
| 2 | 0.52 | 21.15 |
| 3 | 8.85 | 26.92 |
| 4 | 29.69 | <u>40.39</u> |
| 5 | <u>39.58</u> | 9.62 |
| 6 | 18.23 | 1.92 |
| 7 | 2.08 | |
| 8 | 1.04 | |

Source: Field work for the Wheat Study - March 1972.

Fig.6.11.

The greatest number of farmers water their new early varieties of wheat five times during the rabi and their deshi varieties four times (Fig.6.11). 21.00 per cent did water their wheat more than five times, but even though the majority irrigated less frequently, they still applied more water to the new varieties than they did to their deshi wheat. It is interesting that deshi wheat used to be irrigated very rarely. According to the acting Block Development Officer of Bulandshahr, Mr.B.B.Lal, the results that farmers have had from their new varieties as a consequence of irrigation have spurred many of them to try to apply similar techniques to the indigenous varieties and so to increase their yield. Although there are great dangers of the deshi wheat crop being lost if the plants bear too heavily, their yields can be raised by an increase in the inputs and some of the

cultivators appear to be improving their deshi wheat yields by using techniques derived from their knowledge of the requirements of the new high yielding varieties. A difference is apparent in the number of waterings given to deshi and the new wheat, but while one of the original questions of the thesis aimed to see whether farmers were applying traditional techniques to the new varieties, the converse of the situation is found to be true here. Farmers are attempting to apply new techniques to traditionally grown varieties and hence the difference in the farming approach to the new and deshi varieties is not as significant as it could be. In addition to increases in irrigation water, deshi wheat now receives more chemical fertilizer than it did before the introduction of the new high yielding varieties. Previously green manure was the only form of fertilizer used. In rabi 1971-72, 78.00 per cent of the deshi growers applied some chemical fertilizer to their crops which yet again indicates a trend which is moving away from tradition rather than adhering to it.

The number of irrigations varies not only between the early, new varieties and deshi wheat, but also between the early, new, and late new, high yielding varieties of wheat. The late varieties need about five irrigations during their life span, this is one less than the early varieties. They do not need quite so much water because of their shorter life cycle. The majority of late wheat farmers gave four applications of water to the late wheat. Whether this was the influence of the package of practices or merely a chance occurrence would be difficult to say.

The approach to farming the late varieties which are a new concept to the farmers, did not seem to follow the recommendations of the package of practices for the time when the seed should be sown. One cannot help but suspect that the results shown in Fig,6,11, coincide with the package of practices more by chance than by design.

Apart from the number of irrigations to the early and late new varieties, correct timing of water application is very important. The pilot study showed that the farmers found difficulty in remembering exactly when they had watered their fields and also if the supply of water for each irrigation had been sufficient. This second point concerned farmers relying on tube wells as the electricity supply was often cut while the fields were being watered, and the irrigation had to be continued whenever possible. Consequently, details on the frequency of the irrigations had to be omitted from the questionnaire survey. This is unfortunate as this aspect of irrigation is crucial to the success of the wheat crop. The use of the number of irrigations is a poor compromise, but unfortunately it is the only one available and it does give some indication of the spacing between the waterings, always assuming that they were carried out with approximately equal intervals in time between them.

The differences in the approach to farming the new high yielding varieties and deshi have now been considered. The next section will examine the possible causes of the variation in the number of waterings in terms of selected independent variables.

Analysis according to the village from which the farmers were sampled appear to show more of a pattern than any other variable (Figs.6.12, and 6.13).

Frequency table showing the number of times the farmers irrigated their early new high yielding varieties of wheat in each village.

| <u>Village</u> | <u>Number of irrigations.</u> | | | | | | | |
|----------------|-------------------------------|----------|----------|--------------|--------------|----------|----------|----------|
| | <u>1.</u> | <u>2</u> | <u>3</u> | <u>4</u> | <u>5</u> | <u>6</u> | <u>7</u> | <u>8</u> |
| Kolsena | | | 6.90 | 31.04 | <u>55.17</u> | 6.99 | | |
| Sabdalpur | | | | 14.82 | <u>40.74</u> | 33.33 | 7.40 | 3.70 |
| Kurwal-Banaras | | | | 22.58 | <u>45.16</u> | 30.26 | | |
| Akhtiarpur | | 3.23 | 16.13 | <u>45.16</u> | 25.81 | 6.45 | 3.23 | |
| Manakpur | | | 6.45 | 19.36 | <u>45.16</u> | 29.03 | | |
| Chirchita | | | 19.05 | <u>40.47</u> | 30.00 | 7.14 | 2.38 | 2.38 |

per cent
farmers.

Source: Field work for the Wheat Study - March 1972.

Fig.6.12

Kolsena, Sabdalpur and Kurwal-Banaras (Fig.1.4) are all canal irrigated villages, while Akhtiarpur, Manakpur and Chirchita depend mainly on open wells and tube wells (Fig.6.13).

Frequency table showing the main sources of irrigation in each village in rabi 1971-72.

| <u>Village</u> | <u>Source of irrigation water.</u> | | | | | | | |
|----------------|------------------------------------|----------|----------|----------|--------------|----------|----------|----------|
| | <u>1</u> | <u>2</u> | <u>3</u> | <u>4</u> | <u>5</u> | <u>6</u> | <u>7</u> | <u>8</u> |
| Kolsena | <u>53.33</u> | | 20.00 | 3.33 | | | 20.00 | 3.33 |
| Sabdalpur | <u>66.67</u> | | | | 3.70 | | 22.22 | 7.41 |
| Kurwal-Banaras | <u>60.00</u> | | | 3.33 | 3.33 | | 20.00 | 13.33 |
| Akhtiarpur | | | 3.13 | 28.13 | <u>68.75</u> | | | |
| Manakpur | | | 3.13 | 9.38 | <u>87.50</u> | | | |
| Chirchita | | | 11.63 | 20.93 | <u>67.44</u> | | | |

per cent
farmers.

Source: Field work for the Wheat Study - March 1972.

Codes: 1-open well. 2-government tube well. 3-own tube well. 4-neighbour's tube well. 5-own pumping set. 6-neighbour's pumping set 7-canal. 8-pond.

Fig.6.13

Several farmers tried to preserve as many water sources as possible in order to safeguard their water supply, though this showed no relationship with the year of instruction in new techniques of wheat farming as had been thought likely. Field observation indicated that the main reason for farmers not irrigating a sufficient number of times was the unreliability of the water source. It seemed logical to expect the farmers with a greater number of sources of water to supply adequate water to their new high yielding varieties of wheat, and this they appeared to do.

Frequency table showing the proportionate number of irrigations given to the new wheat according to the number of sources available.

| <u>Number of sources available</u> | <u>Number of irrigations.</u> | | | | | | | |
|--|-------------------------------|----------|----------|--------------|--------------|--------------|----------|----------|
| | <u>1</u> | <u>2</u> | <u>3</u> | <u>4</u> | <u>5</u> | <u>6</u> | <u>7</u> | <u>8</u> |
| 1 | | 2.06 | 2.06 | 28.00 | <u>32.26</u> | 14.19 | 4.31 | 7.12 |
| 2 | | 1.15 | 3.52 | <u>46.34</u> | 31.42 | 15.38 | 2.20 | |
| 3 | | | 3.12 | 5.10 | 34.72 | <u>48.69</u> | 8.37 | |

per cent
farmers.

Source: Field work for the Wheat Study - March 1972.

Fig.6.14.

Fig.6.14 shows that the greatest proportion of farmers with access to only one source of water, often not a regular and dependable source, irrigated their fields more often than did the largest proportion of cultivators with access to two sources. Farmers who had access to only one, not very reliable source of water, frequently could not get as much water as they required at each irrigation and so, took every opportunity to

supplement their water shortage by irrigating as frequently as possible. The farmers who had access to three sources of water irrigated their fields far more frequently than did the farmers with access to two sources only. It was the largest farmers and consequently many of the higher caste farmers with some education who had access to more than one source of irrigation water. Fig.6.15. shows the proportion who have access to one, two or three sources of irrigation according to the size of the area cultivated (Fig.6.15) and, according to caste (Fig.6.16).

Frequency table showing the proportion of farmers who have access to more than one source of irrigation water according to the size of the area farmed.

| <u>Bighas (Equivalent in hectares)</u> | | <u>Number of water sources.</u> | | | |
|--|------------------|---------------------------------|--------------|-------------|-------------------|
| | | <u>1</u> | <u>2</u> | <u>3</u> | |
| 1 - 3 | (0.08 - 0.24) | <u>100</u> | | | per cent farmers. |
| 4 - 10 | (0.32 - 0.81) | <u>100</u> | | | |
| 11 - 31 | (0.89 - 2.50) | 75.2 | 16.90 | 7.80 | |
| 32 - 100 | (2.59 - 8.91) | 49.40 | 42.38 | 8.25 | |
| 101 - 321 | (8.18 - 25.99) | 33.33 | <u>58.20</u> | <u>8.33</u> | |

Source: Field work for the Wheat Study - March 1972.

Fig.6.15.

Frequency table showing the proportion of farmers who have access to one or more sources of water according to the caste group.

| <u>Caste group.</u> | <u>Sources of irrigation.</u> | | | |
|---------------------|-------------------------------|--------------|-------------|-------------------|
| | <u>1</u> | <u>2</u> | <u>3</u> | |
| I | 62.00 | 32.45 | <u>5.40</u> | per cent farmers. |
| II | 52.00 | <u>45.70</u> | 2.07 | |
| III | <u>72.40</u> | 26.20 | 1.54 | |

Source: Field work for the Wheat Study - March 1972.

Fig.6.16.

We can conclude that caste and its co-linear variables once again have a significant influence on the number of times a farmer irrigates, although this is to some extent controlled by the sources of water to which he has access. The data in this section are less complete than is required for rigorous analysis as neither the quantity nor the frequency of application of irrigation water could be estimated. They have however, shown that farmers are using different irrigation techniques for deshi and for the new high yielding varieties of wheat, and that the number of irrigations they are supposed to give the new wheat is less, but not a great deal less than the package of practices suggests.

6.5 Insecticide and Pesticide.

In comparison with the previous section, this discussion of the use of insecticides and pesticides will be brief. The first question, as previously, asks - are the farmers using similar pest control methods for the new and deshi wheat; and the second question - are these methods adequate?

Of the 49 farmers sowing both deshi and the new varieties, only one uses any form of plant protection for the new varieties. For the most part the farmers do not use insecticide and pesticide. From discussions in the field, it was clear that they feel that there is no need to waste money when they have never needed to do so before. The rewards of higher inputs of fertilizer and water are often evident, but this is not the case with plant protection. Recent work has shown that losses in the Delhi area through pests average about 15.00 per cent (32). Organizations which lend farmers equipment and which provide demonstrations of the methods of application of pest control chemicals are being encouraged by the government. Although the district figures for the use of insecticides and pesticides has risen very sharply, this is not reflected in the sample. 187 farmers out of 196 used no plant protection measures at all; this falls far short of the recommendations of the package of practices where farmers are urged to use protective chemicals on both seed and plants. A range of chemicals is available to the farmer, the most popular still being D.D.T. No measures have been taken in India as yet to curb the use of D.D.T., the potential danger of this chemical is disregarded, and cultivators are still urged to use it. Work by Srivastava in Uttar Pradesh (33), has shown that the excessive

use of pesticides and insecticides can destroy, or vastly change the fauna in the soil and this may have a considerable influence on the management of the soil. Ultimately, it could reduce the productivity of the land.

One of the greatest dangers with the new high yielding varieties of wheat, is their susceptibility to unknown pests. The moist atmosphere among the dense foliage due to frequent irrigations, is conducive to pest development, and, as their vast tolerance range allows them to be grown over wide areas, a few particularly severe pests could cause large scale destruction.

The replacement of the 'old' with 'new' varieties has destroyed many of the 'raw materials' plant breeders rely on, and as a consequence, the existing reserves of genetic variation are dwindling rapidly (34 and 35). Unless farmers can be persuaded to adopt plant protection measures, the risk of loss of crops through disease must increase. As the genetic resources of the primitive varieties are declining, the food supply of a considerable population could be lost because of the lack of variability in the plant genetic codes (36), and because farmers are unwilling to take any precautions to safeguard their crops.

There is little to add concerning the use of insecticides and pesticides. It seems that where farmers can see the direct benefit of changing a technique, they are prepared to do so, but where the use of chemicals is more of a precautionary measure than a necessity, they prefer not to change their traditional methods, and so the null hypothesis cannot be rejected.

Perhaps if insecticides and pesticides can have such an adverse effect on the soil (37), it is better that less rather than more of these chemicals is used until there is more known and taught to the cultivators about their potential effects. It has been argued (38) that plant protection could rival fertilizer as the most expensive input in the future, if the dwarf varieties continue to be grown. Their lush growth and thick stands are particularly prone to the development of pests, and although the only means of protecting a crop may be through the use of a pesticide, it is alarming to think that the long term effect of the concentrated use of such chemicals could reduce the productivity of the land.

6.6. Harvesting.

The rapid developments in plant breeding and fertilizer production have not been paralleled by the expansion of farm machinery in the study area. There is no difference between the methods of harvesting the new high yielding varieties and the deshi wheat. They are all harvested by hand. Not one of the sample farmers used a combine harvester in rabi 1971-72.

Combine harvesters are available from the BDO. (Block Development Office), where the terms of hire in the Bulandshahr area are, that the farmers pay for the fuel and the time of the operator only. The hire of all types of machinery is, however, attended by many problems. There are insufficient tractors to meet peak demands, and the queues for the machines are too great. Everyone needs a combine harvester at the same time, and this time of harvest is critical. In addition when family labour is available, why should it not be used? According to one farmer, if the harvest is gathered too quickly the family has more time to spend the money. Perhaps the most important reason against using a combine harvester was, that the stalks of the wheat were cut about 15cm. above ground level. The chaff is used for animal fodder, and if the wheat is harvested by hand, it is cut down to ground level and none of the chaff is lost. The quantity which can be saved in this way can be quite considerable. In the study area wheat is still threshed by traditional methods where bullocks tread the ears, and there is no difference between the methods used for the new high yielding varieties and for the deshi wheat.



Plate 12.

Harvesting the wheat by hand.



Plate 13.

Loading the bundles of wheat on to carts.

Source: Field work for the Wheat Study - March 1972.



Plate 14.

Threshing the wheat in the traditional way.
(with bullocks).

Source: Field work for the Wheat Study - March 1972.

While the wheat is gathered and threshed by traditional methods, the chaff is rarely cut by hand now. Most farmers have access to their own or their neighbour's hand threshing machine. This does represent a change in farming techniques, but there is no indication that it is due to the presence of the new high yielding varieties.

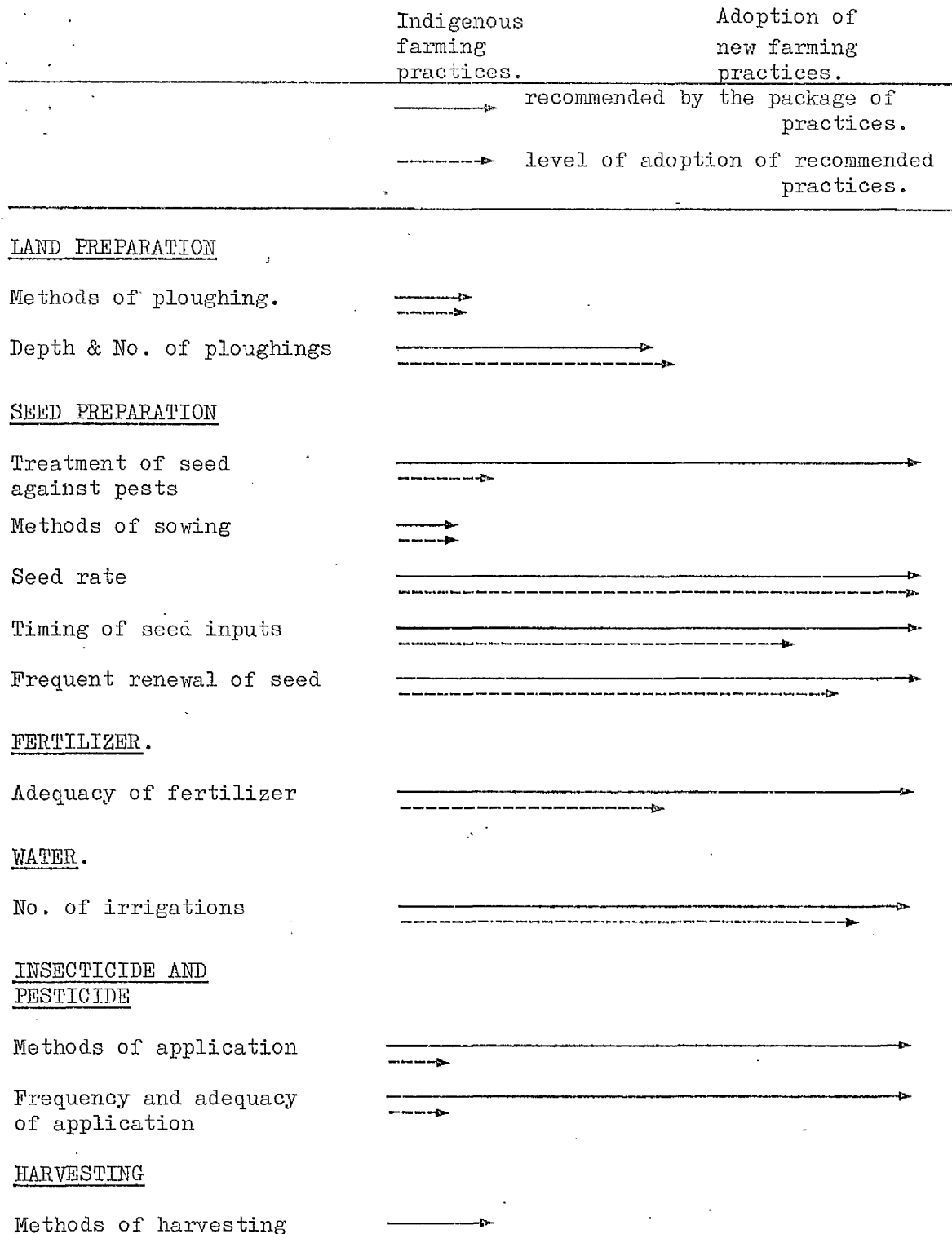
The package of practices has no rules about the methods used for harvesting, but it does urge farmers to harvest their wheat as soon as it is ripe to avoid losses through shattering. Sonalika and Kalyansona are prone to shattering and, despite the introduction of HD 1593 and 1553, the hybrids resistant to shattering, many of the varieties grown are still the older varieties which do shatter.

The other important recommendation is that the individual new high yielding varieties must be kept pure. They all have slightly different maturation periods which are likely to influence the yields. It appears to be the habit of farmers to gather all the bundles of wheat together in one field and, after the threshing, mix them as they once mixed the indigenous varieties. The necessity for keeping strains of wheat pure does not always seem to be an essential consideration to the farmer. Because of this, the proportion of different varieties growing within a field may be as much as ten per cent. Mixtures are always apparent, because different varieties of wheat grow to different heights.

For the most part, methods of harvesting appear to have

changed very little in the period 1965-72. They do not vary significantly between farmers of different caste, or from different villages, or farmers who cultivate different sized farms or have different education levels. These results were confirmed by Allan 1972 in the Harvest Activity Study in Chirchita, one of the Wheat Study villages.(39).

Diagram summarizing the changes from traditional farming, recommended by the package of practices for growers of 'new' wheat, and an estimate of the level of adoption of these recommended practices.



Source: Field work for the Wheat Study - March 1972.

Fig.6.17.

6.7

Conclusion.

Farmers have reacted in different ways to various features of the package of practices. In general two responses have become evident. The first is innovative, in which farmers are trying to put into practice the recommendations of the package of practices, so that their yields increase. The second is to reject selected aspects of the package. Farmers are prepared to change the seed rate, the fertilizer and the water input, but they are unwilling to make use of techniques which reduce the labour intensive nature of agriculture. They feel that these inputs are available to them and they would be no better off at present if they were replaced. Where direct benefit from the use of certain techniques is apparent, farmers are quite prepared to modify their techniques, but if this is not the case and a change in their routine appears to be superfluous, tradition remains the stronger influence.

Fig.6.17 is a highly generalised diagram which summarises the results already considered in detail and which have been quantified as far as possible. It shows whether the dependent variables are moving towards the recommendations of the package of practices, or are remaining firmly with the traditional methods.

Fig.6.17 does show that the farmers are progressing towards the recommendations of the package of practices. The most critical requirements of water and fertilizer may not be adequate yet, but inputs to the new wheat are significantly higher than those applied to the traditional varieties. Most of the methods

of implementing the new techniques, however, have remained the same and show no indication of changing from the labour intensive pattern they have inherited. The next chapter examines the yields the sample farmers have harvested in an attempt to see if the intensity of selected inputs is in any way reflected through the crop yields.

CHAPTER 7.

The relationship between wheat yields and selected wheat farming practices.

The success of the High Yielding Varieties Programme is all too frequently based on the number of participants in the scheme, and not on the techniques that the farmers are using (1). The foregoing chapters have attempted to analyse the various approaches to growing the new varieties of wheat, and to see if the cultivators are prepared to vary their farming practices from traditional methods of cultivation. The data have shown that it is the 'better' farming castes of the study area which are closest to meeting the physical demands of the new wheat (Chapter 6), and these farmers ought, therefore to harvest the highest yields from their wheat fields. The purpose of this chapter is to test some of the results and conclusions derived from the previous chapters, and to try to relate wheat yields to selected inputs.

Information on yield was collected approximately 12 weeks after the harvest, in mid-June, by means of a second questionnaire. By this time of the year, the farmers had completed all their wheat transactions and so could provide details of their harvest. They were visited once again in the villages by three of the original five enumerators, but unfortunately, it was not possible to interview all the farmers who had participated in the first survey. They were not available. However, data for the harvest were collected from 79 per cent of these cultivators, and it was felt that these data were an adequate basis from which to draw tentative conclusions about the study area. Details concerning the second questionnaire are discussed

in Appendix 2.1. In this chapter, yield is the dependent variable in all the analyses. The variables which acted as the dependents in Chapters 4,5 and 6, and which can be grouped together under the heading 'methods of farming', now change their role and become variables which influence yield. These are now the 'independent' variables, in the statistical sense, and so add to the original group of 'independent' variables (Chapter 2. p. 66).

Before the analysis of the variations in yield begin, descriptive information on the yield data will be valuable. Fig.7.1. shows the frequency of occurrences of the wheat yield in ten quintal groupings.

Table to show the variation in wheat yields.

| <u>Quintals/hectares.</u> | <u>Proportion of farmers</u> |
|---------------------------|------------------------------|
| 0.0 - 9.9 | 10.5 per cent |
| <u>10.0 - 19.9</u> | <u>38.1</u> |
| 20.0 - 29.9 | 18.4 |
| 30.0 - 39.9 | 21.7 |
| 40.0 - 49.9 | 12.5 |
| 50.0 - 59.9 | 00.7 |

Source: Field work for the Wheat Study - March 1972.

Fig.7.1.

The distribution is bimodal with 38.00 per cent of the farmers forming the major peak in the 10.0 - 19.9 quintals per hectare group, and a secondary peak in the 30.0 - 39.9 quintals per hectare group (Fig.7.1). With such a situation, a mean

yield accompanied by the standard deviation becomes meaningless as the distribution is far from normal. The mean district yield was 14.48 quintals per hectare in rabi 1969-70 (2), the most recent government statistics available, two years before this Wheat Study. It is interesting that nearly 35 per cent of the sample farmers obtained yields which were below the 1969-70 district yield figure of 14.48 quintals per hectare, while the majority harvested yields above this level. The variation within the yield range is so great, 51.22 quintals, that an attempt will now be made to explain the variation in terms of a selected group of independent variables.

7.1. The relationship between caste and yield.

The higher caste farmers of the area, the Jats, Brahmins and Rajputs had the largest farms, and higher education levels (Chapter 4. p.162), and so the first hypothesis to be set up, examined the relationship between the yield per unit area and the level of caste. As caste is so closely related to the other potentially influential variables, such as education and farm size, the relationship between yield and caste alone was examined, and the analysis with these other co-linear 'independent' variables was omitted, as they added no significant explanation to the results obtained by using caste alone. As caste is nominally scaled, and as the yield data are not ^{rm} normally distributed, nor are they easily transformed to a normal distribution, the Kruskal-Wallis non-parametric analysis of variance test was used. Fig.7.2 lists the mean values of the yields, and shows that the wheat yields of the 'lower' castes of group III (Chapter 2.p.154), fall below those of caste groups I and II, though they were not statistically different according to the Kruskal-Wallis test (3). The data were then analysed at the more detailed scale of caste groups in the villages, but still no statistically significant pattern emerged.

Table showing the mean wheat yields of the major caste groups.

| <u>Caste group</u> | <u>I</u> | <u>II</u> | <u>III</u> |
|--------------------|----------|-----------|------------|
| Mean yield (Q./ha) | 23.83 | 26.77 | 19.61 |

Source: Field work for the Wheat Study - March 1972.

Fig.7.2.

These results contradicted all the predictions made from earlier field work. According to the wheat specialists, the new high yielding varieties are responsive to high inputs of fertilizer and water, in particular (4), and so it seemed reasonable to expect farmers who complied with these demands to have significantly higher yields. In the study area, this result was anticipated for the members of caste group I and some of group II, but not for the members of caste group III. The yields of farmers in these groups, however, were not significantly different. One reason for this insignificant result may have been the poor quality of the data. The problems of collecting information through questionnaires has been fully discussed in Appendix 3.1. , and one cannot disregard the probability that answers from the cultivators were inaccurate. Their willingness to answer the questions, however, suggested that they were not consciously misinforming the enumerators. Problems of collecting information on crop yields are immense, and it is for this reason that sources of yield data are relatively scarce. Although the anticipated results did not emerge when caste and crop yields were related, the data were not discarded but further means were sought to explain the considerable variation which was evident.

7.2. The relationship between fertilizer input and yield.

As a null hypothesis relating caste to yield could not be rejected, other hypotheses were examined. First, the possibility of there being a direct relationship between yield and fertilizer application was tested. The relationship between fertilizer and caste is not perfect, as many higher caste farmers do not apply the requisite quantities of fertilizer, and the converse of this is also true. The quantity of every type of fertilizer required per unit area varied according to its chemical composition and concentration, and according to the requirements of the soil. The only method of assessing the adequacy of the inputs was to express the quantity of fertilizer each farmer used as a percentage of the amount that was necessary for the soil type. A full discussion of the method used is given in Chapter 6. p.280-285.

The Kruskal-Wallis analysis of variance test showed that the yields of farmers who used sufficient or more than sufficient fertilizer, were far higher than those who did not supplement the deficiencies in their soil. The results were highly significant at the 0.1 per cent level of probability. ($H = 27.82$). The mean yields for each of these were 20.24 quintals per hectare for the lower fertilizer input group, and 28.35 quintals per hectare for those using adequate, or more than adequate fertilizer. Both these results are considerably higher than the mean wheat yield of 14.48 quintals per hectare, the most recent figure for the district (5). This figure includes all types of wheat, and although it implies that many farmers are not growing the new varieties as successfully as others, the District Study

shows that the adoption level in rabi 1971-72 in Bulandshahr is 95.00 per cent (6). The yield and fertilizer data were in interval form and could justifiably have been examined by parametric tests by virtue of the sample size, but lower powered non-parametric statistical tests were preferred because the data were not normally distributed, nor were they easily transformed to the normal distribution. Any general trends would still be apparent from the Kruskal-Wallis test, the power efficiency of which is 95.00 per cent (7). This is a highly sensitive test because the conversion of scores to ranks means that individual cases are considered as opposed to groups, as in the chi square test, for example, and so is preferable when data of interval or ordinal scale are available (8).

84 per cent of the farmers were applying less than the required quantity of fertilizer for their particular soil type. Fig.7.3. shows how the frequency curve of the percentage of required fertilizer would be positively skewed, with the main peak being in the 49.00 - 59.00 per cent group.

Nearly 60 per cent of farmers use more than half the chemical fertilizer that is recommended for their fields, so this indicates that fertilizer inputs are higher than they were for traditional wheat when chemical fertilizers were not an integral part of agriculture. The farmers complain that the main cause of their low input of fertilizer is that the chemical fertilizer is not readily available, a problem to be considered more fully in chapter 8, and, on account of this, their yields are lower than they ought to be. Although considerable variation still appears

to exist among the yields of farmers applying above and below the necessary quantities of chemical fertilizer for the area, the general trend shown by the Kruskal-Wallis test is that higher inputs of fertilizer are rewarded with significantly higher wheat yields.

Frequency table to illustrate the adequacy of fertilizer applications.

| <u>Percentage fertilizer requirements</u> | <u>frequency of occurrences</u> | |
|---|---------------------------------|--------------------|
| 0 - 19 | 7.6 | |
| 20 - 39 | 13.7 | |
| <u>40 - 59</u> | <u>27.5</u> | 83.9 |
| 60 - 79 | 19.8 | below 100 per cent |
| <u>80 - 99</u> | <u>15.3</u> | |
| 100 - 119 | 6.1 | |
| 120 - 139 | 6.9 | 16.1 |
| 140 - 159 | - | above 100 per cent |
| 160 - 179 | 0.8 | |
| 180 - 199 | - | |
| Above 200 | 2.3 | |

Source: Field work for the Wheat Study - March 1972.

Fig.7.3.

7.3. The relationship between water inputs and yield.

The other variable of major significance in the life cycle of wheat, is water. The farmers use several different sources of irrigation water, and when wheat yields were compared on the basis of the main type of irrigation by the Kruskal-Wallis test, the results showed no significant difference between the groups under comparison. Although variation between the groups seems to be more significant than variation within each group, the mean yields from fields irrigated by the different sources do show some differences.

Table of mean yields from wheat irrigated from different sources.

| <u>Source of irrigation.</u> | <u>Wheat yield</u> |
|------------------------------|---------------------------|
| No reliable source | 14.22 quintals / hectare. |
| Canal | 19.57 |
| Privately owned tube well | <u>32.01</u> |
| Neighbour's tube well | 25.49 |
| Government tube well | 11.15 |
| Open well, pits etc. | 18.41 |

Source: Field work for the Wheat Study - March 1972.

Fig.7.4.

i. The advantages and disadvantages of tube well irrigation.

16.00 per cent of the farmers who irrigated by private tube well obtained higher yields than all the others with 32.01 quintals per hectare (Fig.7.4). The ground water sources of the doab are immense, and if farmers have access to this source, they are assured of adequate irrigation water. The problem for tube

well operators, however, is the electricity supply which is unreliable and cuts often interrupt irrigation programmes.

The private tube well owner is least inconvenienced by this problem and merely continues to irrigate his fields once electricity is available again. During the peak seasons for irrigation water, and when demand for electricity is high, the fields are often watered at night, as the supply of electricity to urban and industrial areas is maintained at the expense of the rural areas during the day.

The farmer who depends on the government tube well has far greater difficulties. Any interruption during the irrigation means that the farmer loses his water and so is forced to await his next turn before irrigation can be continued. The unreliability of the source must be partly responsible for the low yields harvested by these farmers. It must be emphasised that the farmers who depend entirely on government tube wells are members of caste group III, the group identified with lower inputs (Chapter 6), and the problems of government tube well users do not help to improve their farming techniques. The majority of private tube well owners, on the other hand, are members of caste group I. Irrigation alone may not be the only variable affecting yield, but it does appear to be significant. Farmers who depend on their neighbours' tube wells for water have yields which, according to the Kruskal-Wallis test, are not significantly lower than the tube well owners. The difference could merely represent chance occurrences. These farmers share their neighbours' advantage in having a virtually infinite supply of water, though not of electrical energy for the pumps. Diesel is not a popular alternative energy source with the

farmers, because of alleged higher running costs and the additional maintenance required by diesel installations. Such installations are less convenient than electrical pumping equipment.

ii. Advantages and disadvantages of canal irrigation.

Canal water is also rationed, but the chances of the irrigation being interrupted are more remote than for tube well users. According to the canal irrigation officer in Bulandshahr, the canal irrigation department calculates the total cost of a certain number of irrigations for the area of wheat, grown by each farmer, to a depth of five centimetres over the field. The number of irrigations and the depth of the water which is allowed to stand in the field, usually five centimetres, may be varied by the canal department according to the quantity of water in the canals. As the farmer has paid for a certain quantity of water, he irrigates to the maximum, and only if canal water is short, is he forced to use less water than the plants need. The Kruskal-Wallis test shows that the yields of these farmers at 19.57 quintals per hectare, are not significantly lower than the tube well users, which average 27.11 quintals per hectare. Both sources of water, canal and tube well, are relatively reliable.

iii. The advantages and disadvantages of irrigation from open wells, tanks, lakes, ponds and other surface sources.

Users of open wells are even less fortunate than farmers dependent on canals. Some may have a constant supply of water if the well is pukka (cemented) and deep. If not, the supply of water comes to an end if the monsoon and winter rains are insufficient. Ground water levels have been affected by the

withdrawal of water for irrigation. An area south west of Sikandrabad (Fig.1.4) has been affected to the extent, that users of open wells complain that they cannot draw water, and the development of tube wells in the area has been blamed.

The more enterprising farmer will not depend entirely on one source of water. Disaster through shortage in one source could at least be partially averted by maintaining a second source. With the advent of tube wells however, this policy has been disregarded and farmers have all too often let their wells fall into disrepair. From an interview with the co-operative officer at Gulaothi, one of the most important towns in the north of Bulandshahr district (Fig.1.4), it was clear that farmers with least access to irrigation water, were highest on the credit priority list. It was often in a farmer's best interest to abandon his wells. The more progressive farmer did his best to maintain as many water sources as he could, as it was realised that a complete dependence on one source can often lead to severe losses. Chapter 6.p.294 has shown that the higher caste farmers have the greatest number of sources of water, and even though these farmers are frequently the tube well owners, they are often more forward looking and are prepared to restore their open wells in order to safeguard their water supply as far as possible. Contrary to earlier expectations, yield was not significantly related to the number of water sources. Reasons for this could be that yield data were inaccurate, or that the number of water sources and their reliability were unrelated. The latter possibility could not be further investigated, however, as the finances of the study were limited.

The most unfortunate farmers must be those having no reliable source of water. In this category are included a great many farmers in Bulandshahr district. The results of the District Study (1972) (9), confirm this result. These farmers depend on temporary lakes and ponds and on the water from their neighbours' wells, if they can 'borrow' it. Their yield of 14.22 quintals per hectare is extremely low for the new high yielding varieties of wheat, particularly for Sonalika and Kalyansona, the two most commonly grown varieties in the area. This value compares closely with the 1969-70 district yields of 14.48 quintals per hectare. (10). The Kruskal-Wallis test has shown no significant variation between the groups of farmers using different sources of water. If the water sources are divided into 'reliable' and 'not reliable', however, a significant result is obtained. 'Reliable' includes canals and privately owned tube wells, and the remainder are classed as 'not reliable' sources. The result was significant at the 95.00 per cent level of probability.

Unfortunately none of these data gives any indication of the quantity of irrigation water used, and it is very difficult to assess this with any accuracy. Tube well pumps might be brought to a halt while they are in use and so the irrigation may not be completed. Canal water may be rationed throughout the season, and the amount of water which is used from an open well for each irrigation is almost indeterminable, unless specific measurements are made on a few selected wells. Problems such as these make any results almost meaningless, and so instead, data were collected on the number of irrigations to see if these

could provide any explanation for the variation that exists in the yield data, but it is realised that this too was a compromise for what was really required (Fig.7.5).

The relationship between the number of irrigations and the yield.

The yield data were compared with the number of irrigations by the Kruskal-Wallis analysis of variance test. No significant relationship was present, but an analysis of the number of irrigations according to the main source of water, did provide some explanation for the range in the number of irrigations which extended between zero and eight.

Table showing the proportionate number of irrigations according to the main source of irrigation water.

| <u>No. of farmers</u> | <u>Source</u> | <u>No. of waterings.</u> | | | | | | | |
|-----------------------|-----------------------|--------------------------|----------|-------------|-------------|-------------|-------------|----------|----------|
| | | <u>1</u> | <u>2</u> | <u>3</u> | <u>4</u> | <u>5</u> | <u>6</u> | <u>7</u> | <u>8</u> |
| 15 | Unreliable | | | | 6.66 | 33.3 | <u>53.0</u> | 13.3 | 6.66 |
| 19 | Canal | | | 1.9 | 26.4 | <u>52.8</u> | 17.0 | 1.9 | |
| 24 | Own tube well | | | 4.5 | 22.7 | <u>40.9</u> | 18.2 | 9.1 | 4.54 |
| 73 | Neighbour's tube well | | 1.7 | 13.6 | <u>42.4</u> | 35.6 | 6.8 | | |
| 2 | Government tube well | | | <u>66.7</u> | | 33.3 | | | |
| 6 | Open well, tanks etc. | | | | 33.3 | 33.3 | 33.3 | | |

Source: Field work for the Wheat Study - March 1972.

Fig.7.5.

53.00 per cent of the farmers with no reliable source of water, irrigated six times; this is the recommended number of waterings for wheat according to the package of practices. These farmers found it necessary to irrigate several times; more frequently than most other farmers, because without reliable sources, they were unable to obtain adequate water on each occasion, or had not the means to obtain adequate water. The largest proportion of private tube well owners watered their wheat five times (Fig.7.5), and according to them, each irrigation was sufficient. It is interesting that the peak of the distribution of farmers using their neighbours' tube wells was at four waterings. Owing to electricity shortages, these farmers had to take second place to the owners and sometimes were unable to fulfil the water requirements of the wheat. The greatest variation in the number of waterings was present in this group of farmers. These patterns shown in Fig.7.5. are similar to Fig.7.4. which illustrates the mean yields of the farmers using these same irrigation sources. 53.00 per cent of canal users watered their wheat five times.

There appeared to be far more uniformity in the number of waterings among canal users, than among private tube well users because of rationing. Finally, the low yields of the government tube well users are yet again reflected in the inadequate number of waterings to their wheat, resulting from the problems they have in obtaining irrigation water. The location of their fields in the area 'commanded' by a government tube well, which inhibits private tube well development in that area, forces them to be dependent on an unreliable source. Considerable friction has been generated because government tube well users are not supposed

to have private tube well installations built within a specified range. Government tube wells are frequently damaged and parts stolen by resentful private operators. These government tube well users tended to be the 'poorer' members of the sample with smaller holdings, not large enough to warrant a private tube well according to the calculations of the co-operative bank credit scheme (11).

None of the other statistically independent variables listed in Chapter 2.p.66 showed any relationship with yield. This was predictable, for variables such as plant and seed protection which were only used by nine of the entire sample of farmers, did not have significantly higher yields than the rest. Not even the variation in seed rate was reflected in the yield pattern. This situation was not altogether a surprise as the problems of collecting accurate yield data are immense. Inputs have to be applied to the wheat at critical times during the life cycle of the plant and, other than study the approaches of one or two wheat farmers, it was not possible at such a scale to obtain adequately detailed and accurate data on the timing of material inputs. It was unrealistic to ask farmers exactly when they applied water, fertilizer, pesticides and numerous other needs of the wheat; and sadly, it is this group of variables which might have explained much of the variation in the yield patterns.

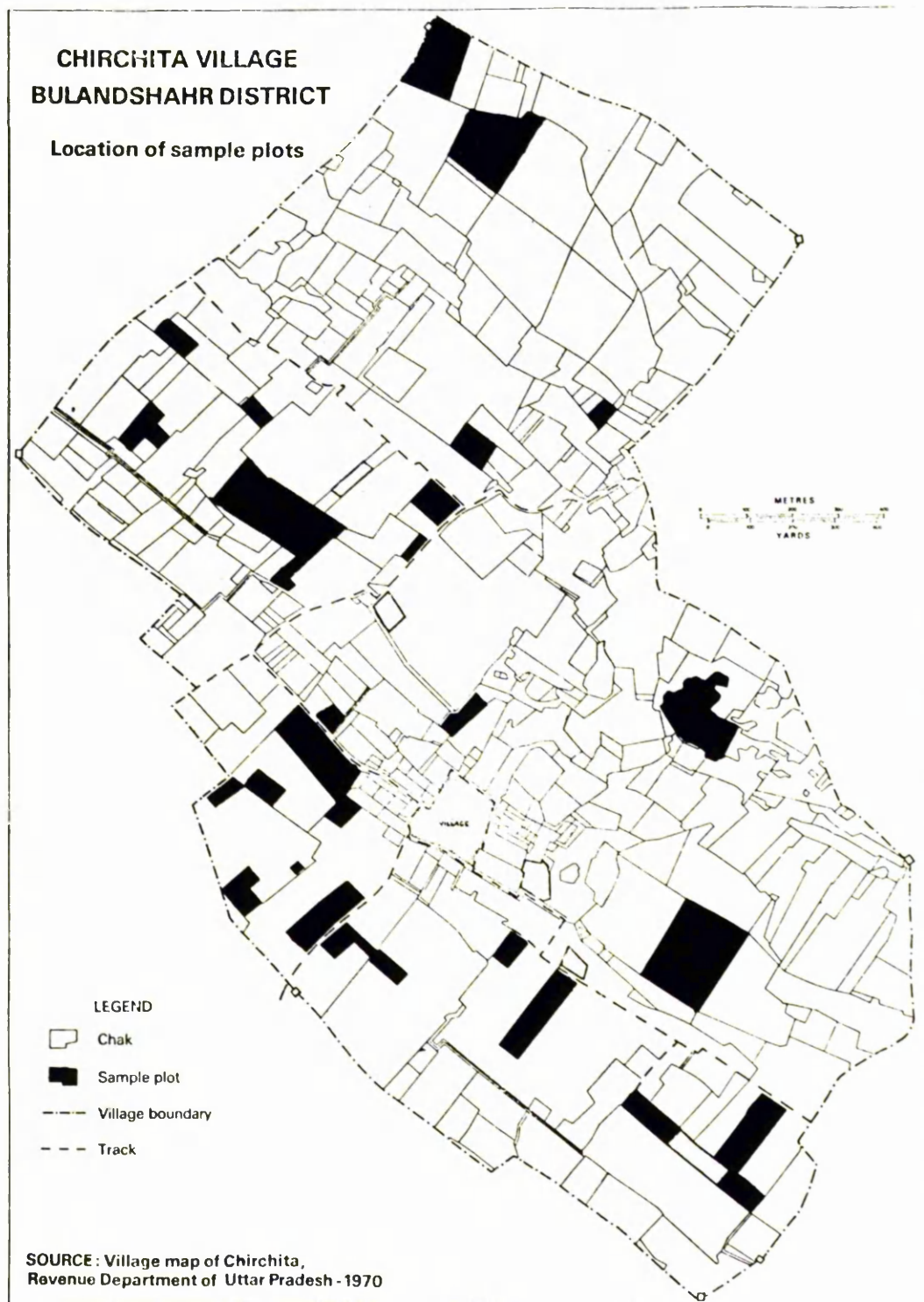
Some data on just one of these variables was obtained however, relating to the week of sowing. This is a critical factor in the life of the wheat, but again no significant

relationship was apparent with the yield. Late sowers did not appear to harvest comparatively low yields. These results conflicted with the work of the Indian Agricultural Research Institute in Delhi, which concluded that the wheat yield was directly related to the length of the maturation period (12). Wheat sown late ripened too rapidly before the grain was properly developed. The majority of the farmers did sow their early wheat in either the first or second weeks of November (Chapter 6.p.271) the time stipulated by the package of practices for sowing the new wheat seed. One final reason must be put forward for the failure of any of the selected variables to explain the range of the yields. The yield data may not be accurate. After meeting the farmers, however, it seemed unlikely that they should deliberately give false information, as they were all willing to take part in the enumeration and a number of enumeration checks were incorporated in the questionnaire where such were possible. If this had not been the case, the answers of the farmers would have been suspect. There remains uncertainty about the ability of the farmers to know their precise production. The questions were asked about 12 weeks after the completion of the harvest, allowing sufficient time for the crop to be threshed. The pattern in assessing production relates to that proportion of the crop which did not reach the market. It is possible that the farmers' estimate of this part of his production is inadequate, and errors of plus or minus ten per cent are very likely, and such a margin of inaccuracy would considerably impair the usefulness of statistical tests and measures of relationship.

The data have shown that the essential requirements of the

new wheat, water and fertilizer, do bear some relationship to the yield data, though in absolute terms, the yields of farmers providing higher input groups do not seem to be in proportion to the quantity of inputs, particularly in the case of fertilizer. According to the farmers, supposedly adequate inputs of fertilizer did not always guarantee high yields as they had been informed they would.

On account of the inadequacies of questionnaire derived data, a second approach was implemented at a more detailed level and by a different method. Crop cutting samples were taken from the fields of each of the farmers in one village, Chirchita (Fig.1.4). These data did not depend at all on the answers of the farmers, and being at a more detailed level, it was hoped that they might provide some insight into the yield variation.

**Fig. 7.6**

7.4. Method of approach to the crop cutting sample.

Field resources limited the crop cutting samples to small areas. Three one metre quadrats were placed in standard positions in each of the 35 fields regardless of their size, and the entire 'contents', that is both the crop and the weeds, were removed from the quadrat (Appendix 2.3). The location of the sample plots in Chirchita village is shown in Fig.7.6, and a full discussion of the sampling scheme is given in Appendix 1.2. Three square metres per plot is a very small sample on which to base any conclusions, but there were two main reasons for cutting such small areas. First, the farmers were not prepared to accept any compensation for the wheat which was cut for the study, so the sample had to be of such a size that it would have little effect on their return. If the cutting sample size had been increased to the level of statistical viability, it would have reached the proportions where the farmers were forced into accepting payment, and the study would not have been able to bear the cost.

The second reason is that in order to ensure the comparability of the field results all the samples had to be collected in exactly the same way. It was therefore advantageous that one person saw that the approach was consistent as far as possible. If however, the sample size had been increased it would not have been practical for one person to supervise the collection of the material and the error margin would have been widened. Despite these reservations, it is relevant to observe that the crop sampling procedure for the Wheat Study compared favourably with the crop cutting samples carried out in Bulandshahr

as specifically for the High Yielding Varieties Programme.

According to Desai (13), a minimum of 300 crop cutting experiments are conducted in a crop season for the estimate of the district yield. Each sample is cut from an equilateral triangle, the sides of which are 20.15 metres (22 yards) in length. The Indian Agricultural Development Programme (IADP.) officer at Delhi in charge of field work gave details of the methods used for collecting the crop samples. Only two samples were cut from each of the IADP study villages, and not in every case were they both wheat. The results of the crop cutting samples taken from Chirchita show that considerable variation exists within the village, and so a sample of two fields, however large, seems a poor basis from which to generalise. The IADP sample covers about 0.01 per cent of the district and although predictions from these data may well be accurate, the considerable variation found to exist in a single village, Chirchita, suggests that the accuracy of district yield estimates based on a relatively small proportion of the district may be limited. However, anyone experienced in the problems involved in crop sampling would accept that 300 samples covering approximately 5.25 hectares, is a large sample. Data from an area such as this forms the basis of IADP estimates for the entire district, and in view of this level of generalisation, one feels justified in examining the crop sample data from Chirchita, and not merely dismissing them as too small and inadequate.

In order to examine whether the data were adequate with respect to accuracy, a number of statistical tests were applied. It would be expected that the three separate quadrats from one field would show similar characteristics and so a chi square

one sample test (14) was applied, and in only three of the 35 fields was there a significant degree of variation between the three quadrats. This implied that conditions were fairly uniform within the three sample quadrats, and so it is assumed, in the entire plot as well. From observation, all the sample fields appeared to have an even covering of wheat and not to be unduly patchy. Seeding was done mainly by a dibbler, a device attached to the wooden plough and through which seed is trickled. This method assures a more even coverage of the land than does broadcasting the seed by hand. The only fields where the wheat looked patchy were in the poorer drained areas where reh was present on the surface of the soil.

The yield results from the crop cutting samples showed almost as great a range as the 51.47 quintals recorded by the questionnaire data. The highest frequency of occurrence in the crop sample fell within the 20.00 - 29.99 quintals per hectare group (Fig.7.7), the comparison with the group below for the questionnaire survey. It was unlikely that the patterns of the two frequency curves would coincide, because of the differences in the sample. The Jats and Brahmins of Chirchita village were some of the most progressive farmers in any of the villages studied. For instance Ch.4.p.179 shows their readiness to adopt the new varieties in comparison with the Muslim-Rajputs of Chirchita. It is not therefore surprising that the frequency table (Fig.7.7) shows the msjority of the farmers with yields between 20.00 and 50.00 quintals per hectare, as 69 per cent of this reduced sample of farmers were members of caste group I, and hence the 'progressive farmers'.

Frequency table of wheat yields from the Chirchita crop sample study.

| <u>Wheat yield (Q./ha).</u> | <u>Proportion of farmers.</u> |
|-----------------------------|-------------------------------|
| 0.00 - 9.99 | 3.03 per cent |
| 10.00 - 19.99 | 12.12 |
| 20.00 - 29.99 | <u>39.39</u> |
| 30.00 - 39.99 | 30.30 |
| 40.00 - 49.99 | 12.12 |
| 50.00 - 59.99 | - |
| 60.00 - 69.00 | 3.03 |

Source: Field work for the Wheat Study - March 1972.

Fig.7.7.

The yield results from the crop sample plots were correlated with the results from the formal harvest questionnaire conducted in June, using the Spearman Rank correlation. A coefficient of 0.724, highly significant at the 0.1 per cent level of probability was the result. All a direct correlation implies is that the data vary in the same way. This they did, though questionnaire results were about 20 per cent lower than the estimate from the field samples. Two of the cases had to be abandoned because error either in the sample cutting or in the analysis, was detectable, as the difference between the actual and the predicted yields from the field samples, was over 100 per cent. Unfortunately it was not possible to check the source of the error as field conditions had changed.

The similarity between the answers of the farmers and the

crop cutting samples collected independently of the questionnaire data was encouraging, although the possibility of this relationship being due to chance could never be ruled out.

Under such conditions when the data are in doubt, because of their scarcity, the only alternative is to refer back to observations made in the field and to decide subjectively whether or not the data are representative of the area. In this case it was judged that the results did reasonably represent field conditions, and so the next part of the chapter is based on the analysis and results of the data from the crop cutting samples.

7.5. Analysis of the data from the wheat crop samples.

Eight variables were analysed from each wheat sample.

These particular variables were isolated because they had either seemed important factors during the field work, or they had been suggested by V.S.Mathur, the chief wheat breeder at the Indian Agricultural Research Institute, Delhi, as significant to the study. The contents of each quadrat were treated as a separate sample so that variation between the samples in a field could always be examined. The data were analysed at the Indian Agricultural Research Institute, Delhi and the three samples from each field were analysed as $3 \times 35 = 105$ separate samples.

The variables measured from the sample of wheat were

1. The mean height of the wheat.
2. The dry weight of both wheat and straw.
3. The dry weight of the grain.
4. The mean length of the ears of wheat.
5. The mean weight of the ears of wheat.
6. The weight of 1000 grains of wheat.
7. The number of plants per unit area.
8. The protein content of the wheat.

Analysis of the questionnaire data had not explained all the variation in the yield results, and it was hoped that by looking at the wheat in more detail, and at a different level, some further explanations for the range in the yield might emerge. In the first part of the analysis, yield was taken to be the grain harvested. In the second, the concept of yield has been expanded to include several other variables of the wheat plant.

Of these other variables which were measured, the height of the plants showed very little variation at all. Differences that were present were largely explained by the characteristics of individual varieties.

Table showing the mean heights of the four main varieties identified in the wheat samples.

| | <u>Height.</u> |
|---|----------------|
| 1. C273 and 306 (indigenous improved varieties) | 128.00 cm. |
| 2. Kalyansona | 98.56 |
| 3. Sonalika | 93.44 |
| 4. HD.1941 and HD.1944 (triple gene varieties) | 79.67 |

Source: Field work for the Chirchita Crop Sample Study
March and April 1972.

Fig.7.8.

The indigenous improved varieties are the tallest plants, these are the single gene varieties; the semi-dwarf varieties of Sonalika and Kalyansona are shorter, and the triple gene varieties of Hira and Moti - HD.1941 and HD.1944 have even stronger dwarf characteristics. The differences in height of the wheat are apparent in the field, and were found to be statistically significant at the 0.1% level of probability when tested with the chi square one sample test. (Chi square = 12.436). These differences are very apparent among the different varieties in the field. The average length of the ears did not vary a great deal, on average they were 8.27 cm. long and ranged between 7.00 and 11.50 cm. Though this was not a useful index

as the grains at the base of the ear were often shrivelled and deformed, and so the size of the ear gave no accurate indication of the grain yield.

The four variables which showed the most variation among the yield data were

1. The weight of the threshed grain.
2. The mean weight of the ears in each sample.
3. The weight of 1000 grains of wheat.
4. The protein content of the wheat.

It was thought that these variables would be closely related to each other, and it seemed reasonable to hypothesize that high yields would be obtained from well developed wheat with well developed grains. Another characteristic of the new high yielding varieties of wheat is their high protein content. The results of the Indian Agricultural Research Institute have shown that on average, Sonalika contains about 13.50 per cent protein, Kalyansona 13.20 per cent (15), and the triple gene varieties contain about 10.00 per cent. The indigenous varieties contained about 10.00 per cent protein (16). It is relevant to note that recent experiments discussed at the FAO World Food Conference have shown that protein need form no more than five per cent of an adequate daily calorie intake for a 'healthy' existence (17). The Indian government is working on the principle that no definite conclusions have been reached on the proportion of protein necessary, so it is better to increase the protein content because it can do no harm. The measurement of the protein content in wheat according to V.S.Mathur, the chief wheat

breeder at the Indian Agricultural Research Institute, Delhi, is one method of estimating whether fertilizer and water inputs have been adequate, or not. Sufficient fertilizer and water, together with proper timing of these inputs should produce wheat with a protein content at least equal to the mean for the particular variety. The assumed relationship between these four yield variables however, did not exist among the sample data, and so the relationship between each of these four and the group of independent variables was examined separately.

i. The relationship between caste and yield estimated from the crop sample.

The absence of a significant relationship between caste and yield using the questionnaire data was a surprise result (Chapter 7. p.310). In Chirchita, however, when crop cutting yield data were used, there was a highly significant difference between the yields of the Jats and Brahmins, the members of caste group I, and the Muslim-Rajput members of caste group III. There were no members of caste group II, the Lodhas and the Gujaras in Chirchita. The Kruskal-Wallis test showed that the difference was significant at the 0.1 per cent level of probability ($H = 24.96$). This result conflicts with the strength of the caste-yield relationship which emerged from the questionnaire data. It must be said however, that qualitative observation showed the Jats and Brahmins of Chirchita to have far superior wheat fields than the Muslim-Rajputs. These two groups were probably at either end of the range of yields, and so showed a significant difference.

ii. The relationship between fertilizer inputs and yield estimated from the crop samples.

The possible influence of fertilizer and water on the total grain harvested was analysed once more. There was no direct, linear relationship between the percentage of the recommended dosage of fertilizer and yield; the Kruskal-Wallis test however, showed that the 37.00 per cent of the sample farmers who used adequate, or more than adequate fertilizer, reaped significantly higher yields 99.00 per cent of the time, than did those farmers who used less than they ought (Fig.7.9) ($H = 27.82$). These results confirmed the conclusions of the larger sample based on the questionnaire material. Despite significantly higher inputs however, the variation in yields within both groups was large.

The question why some farmers who claim to apply adequate quantities of fertilizer and still harvested yields below the district mean, remained unanswered. The relationship was by no means a perfect one and the main value of the results was that they confirmed the earlier results which were collected at a different level and by a completely different method.

Table showing the range of yields from wheat which had received adequate and inadequate fertilizer.

| | <u>Inadequate fertilizer</u> | <u>Adequate fertilizer</u> |
|---------------|----------------------------------|--------------------------------|
| range | | |
| highest yield | 61.20 | 53.50 (Q./ha.) |
| lowest yield | 9.46 | 20.03 |
| mean yield | 25.50 | 39.87 |

Source: Field work for Chirchita Crop Sample Study.
March and April 1972.

Fig.7.9.

iii. The relationship between water inputs and yield estimated from the crop samples.

The relationship between the yield and the irrigation variables were also similar to the results based on the questionnaire material (Chapter 7.p.315). Chirchita, the village from which the crop cutting samples were drawn, was watered mainly by electric tube wells and supplemented by open wells. Farmers who irrigated their fields by private tube well had far higher yields than those who used government tube wells or ordinary wells. The Kruskal-Wallis test shows a significant difference at the one per cent level ($H = 7.69$). The mean yield of farmers using their own tube wells was 35.66 quintals per hectare, which was not significantly higher than those farmers who did not own private tube wells, but had access to them. The mean yield for farmers in the latter category was 29.50 quintals per hectare. These were both very much higher than the yields of farmers irrigating from government tube wells. They had a mean yield of 15.28 quintals per hectare. These differences are borne out by the Kruskal-Wallis test.

Open wells often run dry if winter rains have not been heavy enough to supplement the recharge from the previous monsoon, and so these are unreliable sources of irrigation water. Farmers irrigating from government tube wells harvested less wheat per unit area than did the rest of the sample farmers. The main fault with government tube wells is that if the electricity is cut off during a period of irrigation, the farmer cannot start to irrigate again until his next 'turn', hence he loses part of his water. Private tube wells are the most reliable source of irrigation water, and this appears to be

reflected in the significantly higher yields. These findings correspond with the results of the formal questionnaire survey on yield (Chapter 7.p.315).

iv. The relationship between the plant variables and the yield estimated from the crop samples.

In an attempt to assess the wheat yields more accurately, 1000 grains of wheat were arbitrarily taken from each sample and weighed so that the mean grain weight could be determined. In the field, the seemingly 'better' crops appeared to support the largest ears, and one would have thought, the largest grains of wheat, though it was not possible to estimate this during the field work. The first hypothesis tested for a relationship between the mean yield from each sample field and the mean weight of the straw. This was used as an index of the size of the plant. Somewhat surprisingly, no significant relationship was apparent between these two variables, and the only plausible explanation is a qualitative one.

According to the farmers in the sample villages, the quantity of the inputs is not the only factor to be considered in wheat farming. The times of application are also significant. While the wheat is ripening, the dessicating loo winds (a local climatic factor), blow across the Ganges plain from Rajasthan, and if the wheat is watered while these winds are blowing, the grains shrivel, the weight of the grain decreases and so does the harvest. The farmers are taught by extension workers that the new wheat should be watered between intervals of length stipulated by the package of practices, the publication by the Ministry of Agriculture, showing farmers the theoretical approach

to farming the new high yielding varieties (18). Many farmers who tried to follow these instructions watered their wheat when the loo winds were blowing, merely because it was the correct time during the life cycle of the plant to do so. Unfortunately, it was not possible to acquire any quantitative material on this aspect of the study as each farmer could not provide accurate information on the numerous dates of each of his irrigations.

The lack of significant relationship between the yield and the number of waterings is predictable with the qualitative explanation for low yields given by the farmers. As the ripening period of the wheat progresses, the chances that the loo winds will be blowing are greater, as they start in early February and increase until the July monsoon arrives. The probability of farmers watering their fields when temperatures are too high, therefore increases with the number of irrigations. This explanation results entirely from the questions put to farmers during the second period of enumeration when data were collected on yield. It was interesting that the farmers in each of the six villages gave similar explanations for low yields and there were no social links between the members of one of these villages and the next. No further data were available on this point, but the acting Block Development Officer in Bulandshahr, Mr.B.B.Lal, and the chief wheat breeder at the Indian Agricultural Research Institute, Delhi, Mr.V.S.Mathur, both confirmed that the explanation provided by the farmers was highly probable. Water applied to the wheat while temperatures were too high could be detrimental to the yield. Work by Dutton (1972) (19) on wheat in Tunisia has shown that yields vary according to temperature

changes during the growth period of the plants. The effect of the Sirocco wind is significant and so it seems reasonable to suggest that the similarly dessicating loo winds of the Ganges plain could equally be a force which affects wheat yields.

Failure to understand fully the ecological demands of the new wheat varieties is one of the main reasons for the so called 'failure' of the Green Revolution (20). New breeds of wheat are tried and tested under certain conditions, and released for general use. Agriculturalists all too frequently fail to realise that habitat factors may vary from area to area, and until these differences from the home breeding ground of the species can be isolated and the effects understood, chance must continue to play a significant part in determining wheat yields.

Time of irrigation could well have an effect on the harvest, but it is unlikely to be the only influential factor. Another factor, the number of plants per unit area, was found to vary quite considerably from field to field, and the more dense the spread of plants, the better their physical condition seemed to be. One would expect that thinly scattered seed would have less competition for soil nutrients and so would be more likely to succeed, but on the contrary, these fields seemed to support plants of the poorest quality.

Poor quality wheat could well have related to poor soil and drainage. The latter is difficult to control, but the former can be improved by the addition of chemical fertilizer, for example. Observation showed fields of dense healthy wheat

alongside plots where the condition of the wheat was poor and it was felt that variation in the condition of the plants was more often a reflection of management methods rather than overall soil conditions in the area. Earlier analysis of soils of the area had shown relatively little difference either within or between the study villages.

The number of plants in each quadrat had been counted in the field and this value was related to the mean dry weight of the plants in each quadrat. A Spearman Rank correlation co-efficient of 0.68 significant at the .01 level of probability (21) was obtained, so showing that the fewer the plants in an area, the smaller their size. The number of plants per unit area was compared with the seed rate, but no significant result was obtained when the Spearman rank correlation was used. This was anticipated because of low variation in the seed rate (Chapter 6.p. 264) and greater variation in the number of plants which had germinated. The possible reasons for this will be discussed later in the chapter (p. 344-346).

Observation showed that one of the main factors which hindered plant growth was the presence of weeds. In none of the fields sampled for crop cutting experiments did weeds, defined as any plants other than new or indigenous wheat, cover more than five per cent of the metre quadrats. The weed problem was not significant in this particular village, Chirchita, but it is in many others. Although this section does not relate directly to the area covered by the crop sample, it is none the less relevant to the chapter which examines potential influences on the growth and yield of wheat. One of the main sources of weeds

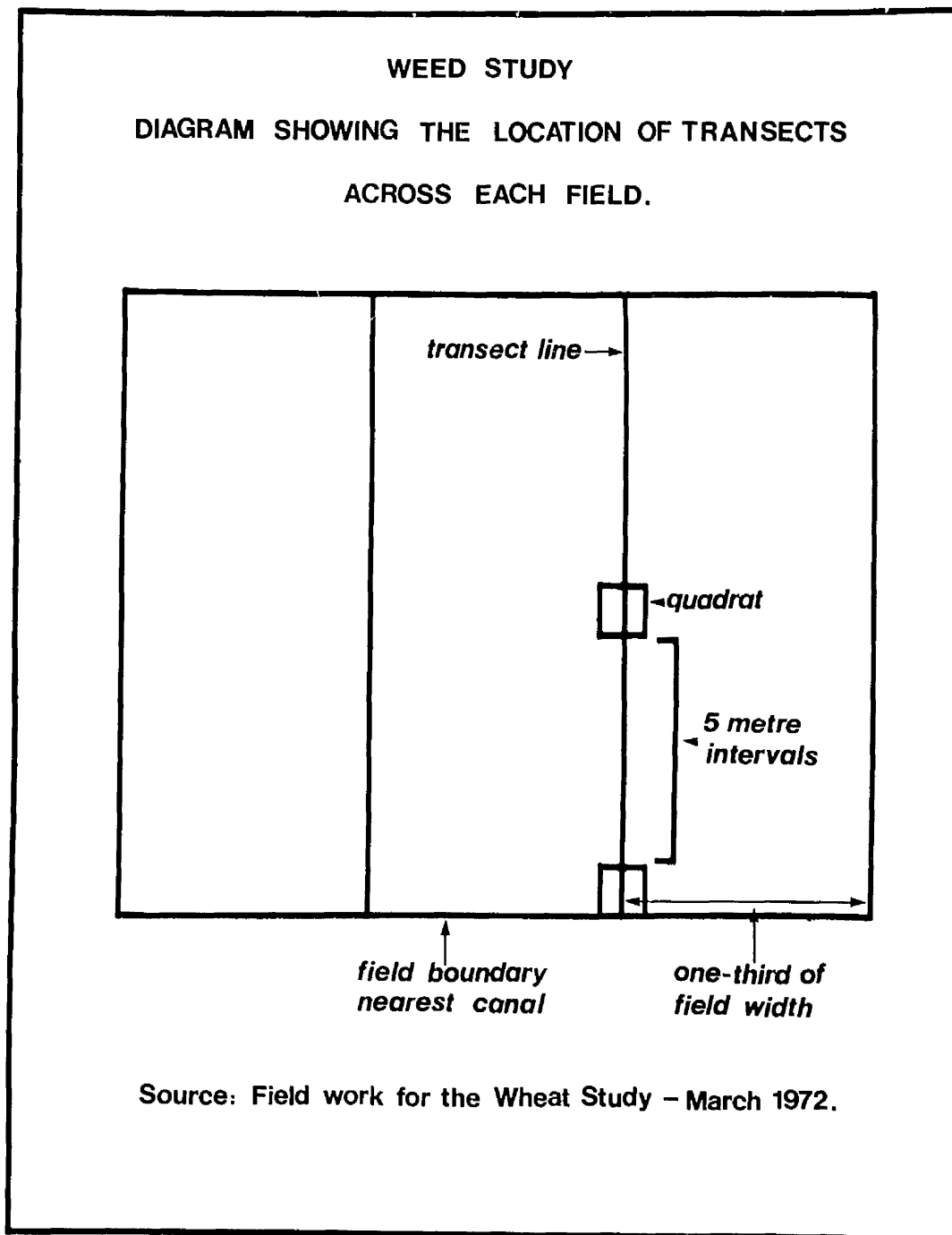


Fig. 7.10

is the canal system. Seeds float down the distributaries and when the water is turned on to the fields, the seeds are deposited and germinate among the wheat. As the initial irrigation of the fields takes place before the wheat is sown, the weeds have a head start. This could be one of the reasons for the lower yields in the wheat fields of the canal villages in the sample. It is a digression from the crop sample study, but it is worth giving brief consideration to some field work carried out on the weed distribution in fields in a canal village.

The village in question was Sabdalpur, one of the three sample villages which receives water from the canal system. The weeds in the fields bordering the canals were extremely dense and decreased in density with distance from the canal or subsidiary irrigation channel. Frequently the weed cover was so dense that the wheat had been choked leaving only a few, isolated plants, or perhaps none at all. These problems of weed pests were almost absent in the tube well villages where the water was relatively free from transported material, and so, in the crop sample study the problem did not arise. A minor study was carried out in Sabdalpur, a canal village of ten fields arbitrarily chosen, which were alongside the canal distributary or one of the irrigation channels leading from it. Two transects were taken across each field at right angles to the canal (Fig. 7.10).

The transects were taken at approximately equal intervals along the field and with a similar distance between them (Fig. 7.10). Quadrats were then placed at five metre intervals and the percentage weed cover was recorded by the Braun Blanquet rapid survey method (22), and 12 quadrats were examined in each transect.

Table showing the change in weed cover in ten wheat fields with increasing distance from the edge bordering the canal.

Increasing distance from edge of field nearest canal.

Quadrat number.

| <u>Percentage weed cover.</u> | <u>1</u> | <u>2</u> | <u>3</u> | <u>4</u> | <u>5</u> | <u>6</u> | <u>7</u> | <u>8</u> | <u>9</u> | <u>10</u> | <u>11</u> | <u>12</u> |
|-------------------------------|-----------|----------|----------|-----------|-----------|----------|-----------|-----------|-----------|-----------|-----------|----------------------|
| below 1 | | | | | | 2 | 4 | 8 | <u>16</u> | <u>20</u> | <u>18</u> | <u>20</u> quadrats |
| 1 - 10 | | | | | 2 | <u>8</u> | <u>14</u> | <u>12</u> | 4 | | 2 | furthest from canal. |
| 11 - 20 | | | | | | 6 | 2 | | | | | |
| 21 - 30 | | | | 2 | <u>10</u> | 2 | | | | | | |
| 31 - 40 | | | | | 6 | 2 | | | | | | |
| 41 - 50 | | | | <u>10</u> | 2 | | | | | | | |
| 51 - 60 | | | <u>8</u> | 8 | | | | | | | | |
| 61 - 70 | | 4 | 6 | | | | | | | | | |
| 71 - 80 | 2 | 2 | 4 | | | | | | | | | |
| 81 - 90 | 4 | <u>8</u> | 2 | | | | | | | | | |
| 91 - 100 | <u>14</u> | 6 | | | | | | | | | | |

Total 20 quadrats (2 quadrats from each of 10 fields).
 quadrat
 nearest
 canal.

Source: Field work for the Wheat Study in Sabdalpur.

March 1972.

Fig. 7.11.

The results in Fig.7.11 show that the wheat has a very poor chance of survival nearest the field edge bordering the canal distributary. This area is the first to be affected by irrigation water and the cover of weeds, mostly Ranunculaceae, was almost complete. Losses due to weed pests must have been high, particularly in the smaller fields, and even though weed pests did not have a significant effect in Chirchita, the tube well irrigated village where the yield study was carried out, they would have been significant had the study been conducted in a canal irrigated village. For this reason, the additional study in Sabdalpur is relevant to this section on wheat yields.

Although weeds did not have a significant effect on the wheat yield in Chirchita through reducing the crop cover, the number of plants per unit area did show considerable variation in the study village and could well have influenced crop production. As the crop density would appear to relate directly to the seed rate, the relationship between the wheat yields and the seed rate was examined. Data taken from the questionnaire shows that there was no significant relationship between these two variables, and also that the answers of the farmers showed that there was little variation in their seed rate. The crop sample study, however, found considerable variation in the number of plants per unit area and so this factor was combined with an estimate of the individual grain weight from each sample, and the quantity of seed per unit area which had germinated, or at least survived, was calculated from this. This estimated seed rate showed a far greater range than the original seed rate and it was much lower. Fig.7.12 compares the proportion of seed per unit area

which survived with the original seed rate, obtained from the questionnaire data. 97.00 per cent of the farmers had sown 86.45 kg. of seed per hectare (7 kg. per bigha) or more, and in 63.64 per cent of the cases the plant survival rate fell below the original seed rate.

Table comparing the estimated survival rate of wheat seed with the quantity of seed that was sown.

(Based on results of crop cutting samples)

| Percentage. | | Percentage. | |
|------------------------|------------------|---------------------------------------|---|
| | | Estimated survival rate of wheat seed | Seed rate according to the questionnaire data |
| <u>Kg. / bigha</u> | <u>Kg. / ha.</u> | | |
| 2.0 - 2.9 | 24.7 - 36.9 | 5.9 | |
| 3.0 - 3.9 | 37.0 - 49.3 | 11.8 | |
| 4.0 - 4.9 | 49.4 - 61.6 | <u>20.6</u> | |
| 5.0 - 5.9 | 61.7 - 73.9 | 14.7 | |
| 6.0 - 6.9 | 74.0 - 86.3 | 14.7 | 2.9 |
| 7.0 - 7.9 | 86.4 - 98.7 | 17.6 | <u>64.7</u> |
| 8.0 - 8.9 | 98.8 - 111.0 | 2.9 | 26.5 |
| 9.0 - 9.9 | 111.1 - 123.4 | 5.9 | 2.9 |
| 10.0 - 10.9 | 123.5 - 135.7 | 5.9 | 2.9 |

Source: Field work for Chirchita Crop Sample, Study.
March and April 1972.

Fig.7.12.

The proportion of the seed which had germinated and survived the growing season showed a significant relationship with the grain yield when examined by the Spearman rank correlation. The coefficient of 0.774 was highly significant

at the one per cent level. This low survival rate of seed seemed to provide a logical explanation for the large quantities of seed farmers were sowing for their early new varieties. A mean seed rate of 96.58 kg. per hectare is far in excess of the 25 - 35 kg. necessary for most of the early double gene varieties. The margin of 10 kg. allows for varietal differences. For instance, Kalyansona requires 25.00 to 30.00 kg. per hectare, while Sonalika, which theoretically has slightly lower yield capabilities (23), needs a seed rate of 30.00 to 35.00 kg. per hectare if equally high yields are to be maintained. The only feasible explanation is that an extremely high seed rate can compensate for deficiencies in the seed quality.

It is easy to speak of high yields relative to high input levels, but other variables such as time of the inputs are also significant. Unfortunately, it was not possible to obtain a great deal of information on this aspect. It has been shown by the Indian Agricultural Research Institute, Delhi that sowing either too early or too late can affect yields because the grain may not have a chance to mature properly (24). The majority of the farmers however, did sow most of their seed at the correct time, though there were considerable variations from the theoretical pattern in the case of the second sowing of early wheat and the late varieties (Chapter 6.p. 271 & 4). If the maturation of the grain is in any way hampered, yields may drop slightly or even significantly, but what is worse is that much of the wheat may be sterile and incapable of producing a crop the following year.

Similarly, if the wheat is watered at the wrong time the

grain shrivels and is deformed and the yields drop. Many of these grains are sterile. Mr.V.S.Mathur, the chief wheat breeder at the Agricultural Research Institute, Delhi, pointed out the significant part of the harvest that was all too often sterile 'grain' and not fertile 'seed'. Unfortunately, while the wheat from the crop cutting samples was being stored at the Indian Agricultural Research Institute, Delhi, much was destroyed by weevils and, so no further experiment could be carried out to see what proportion of the seed could germinate. It is very important that poor farming techniques during one season can affect more than just the wheat yield of the one particular rabi season. The yield of harvests to come can also be affected, particularly if the seed is not renewed frequently. It is possible to see why so many farmers claimed that their yields had fallen although they had tried to follow the rules of the package of practices. Unfortunately, many farmers do not renew their seed from government organizations such as the National Seeds Corporation. They exchange seed with their neighbours. They claim that this is to prevent the development of parasites in one area. It is claimed by many authorities, for example, Mr.V.S.Mathur of the Indian Agricultural Institute, Delhi, that there is no genetic drift in wheat as there is in rice. Theoretically, it would be possible to maintain a pure strain of wheat indefinitely. The true reason for the renewal of seed after four years was never discovered, but from the relationships between the seed rate and the plant survival rate, it seems that much of the plant produce is infertile and so must lead to lower harvests each year if the seed is not renewed frequently.

Relating this to one of the original independent variables,

it was the higher caste farmers, the Jats, Brahmins and Rajputs who had the lowest seed rates of all the sample farmers, but when the frequency curves of the seed rates among the three caste groups were compared by the Kolmogorov-Smirnov test (25), there was no significant difference, showing that the variation which existed was probably due to chance. The most important feature of the seed rate data is that even the lowest levels were nearly three times that which should have been necessary (Fig.7.13).

Table showing the mean seed rate used by each caste.

| <u>Kg. / bigha</u> | <u>Kg. / ha.</u> | <u>Caste group.</u> |
|--------------------|------------------|--|
| 7.9 | 97.57 | I. Jats, Brahmins, Rajputs. |
| 8.3 | 102.51 | II. Lodhas and Gujars. |
| 8.05 | 99.42 | III. Muslims, Muslim-Rajputs, and Chamars. |

Source: Field work for the Wheat Study - March 1972.

Fig.7.13.

The Jats and Brahmins, members of caste group I, did tend to have the larger holdings in Chirchita. They had access to private tube wells while the government tube wells were used by the Muslim-Rajputs and Chamars of the sample, the members of caste group III. It is still almost impossible to discover which variables have the greatest effect on yield; but it does seem that such influential variables may act over more than one season, and their effects may be cumulative.

The final variable from the crop sample which showed some variation was the protein of the wheat. This too was calculated for each of the 105 samples of wheat harvested from Chirchita at the Indian Agricultural Research Institute in Delhi. These details were provided by Dr. Austin of the wheat breeding section (Fig.7.14).

Comparison between the theoretical and the actual protein content of the field wheat samples.

| <u>Variety</u> | <u>Theoretical protein content</u> | <u>Actual protein content of field wheat samples.</u> |
|-------------------------------|------------------------------------|---|
| Indigenous improved varieties | 10.00 | 7.93 per cent |
| Kalyansona | 12.00 | 10.07 |
| Sonalika | 13.00 | 9.87 |
| Hira and Moti (triple gene) | 14.00 | 13.77 |

Source: Theoretical values obtained from Dr. Austin, wheat breeding section, Indian Agricultural Research Institute, Delhi - September 1972.

Actual protein content from crop sample study in Chirchita village - March 1972.

Fig.7.14.

According to Mr. V.S. Mathur of the Indian Agricultural Research Institute in Delhi, the protein content should reflect the adequacy of the water and fertilizer inputs and so these data should conform to or conflict with the answers the farmers

gave on the quantity of inputs into the wheat. Theoretically, adequate fertilizer and timely applications of water should produce high yields of wheat and so the protein content of each sample was related to the one thousand grain weight to see if there was any significant relationship between these variables.

There was no reason to relate the protein content to the mean yield because a differing seed rate could give rise to different yields and the protein content need show no relationship with this at all. The thousand grain weight however, could show a relationship between protein content and yield, and so the Spearman rank correlation was used to test for the presence of a relationship. A coefficient of 0.45 was obtained which was just significant at the 95 per cent level of probability. The data were well scattered and the significant result looked as though it may have been purely chance. Many of the lighter grains appeared to have the higher protein content and this seemed to be inexplicable. The conclusion finally reached after examining all the samples in conjunction with the protein results was that many of the high protein content samples had shrivelled grains. If for some reason the grain shrivelled and its total mass decreased, the protein content which is only a relative measurement could increase significantly as it is unaffected by changes in the mass of the grain. This could explain the lack of relationship and the seemingly high protein in the case of some low grain weights.

According to Mr.V.S.Mathur of the Indian Agricultural Research Institute in Delhi, protein content varies in relation

to inputs of fertilizer and water as these are two variables of great importance in the life of the plant. No data were available for the quantity of water which farmers had used and there were no relationships of any significance between the number of irrigations or the source and the protein content of the wheat. Fertilizer data did, however, provide some interesting results in this context. The Spearman rank correlation was once more used, and a coefficient of 0.76 which was highly significant at the 0.1 per cent level of probability. This was pleasing mainly because it did confirm the answers given by the farmers concerning their fertilizer inputs.

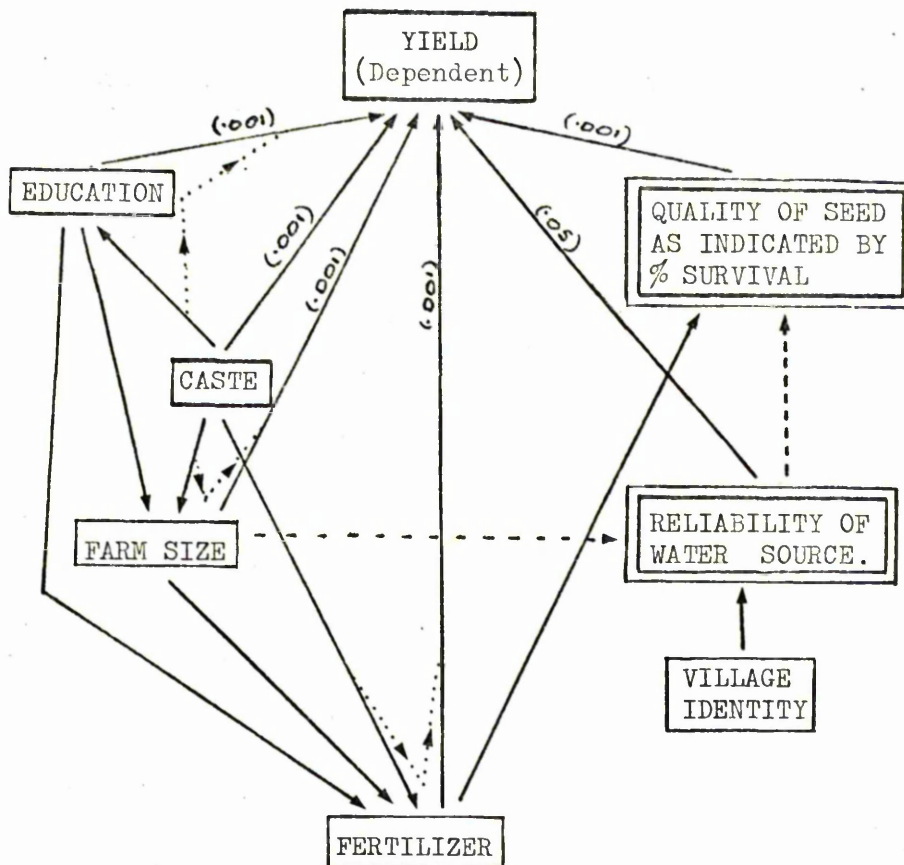
7.6. Conclusion.

In conclusion, the variables which appear to have greatest significance on the wheat yield from the questionnaire data, are sufficient fertilizer and a reliable source of water. It was surprising that caste and the other variables with which it is co-linear, such as farm size and education level, provide no significant explanation for the variation within the yield. The reason for this is probably that Chirchita contains some of the best farmers of caste group I, the Jats and Brahmins, and some of the worst of caste group III, mainly Muslim-Rajputs. It was interesting to find that there was almost no communication between these two groups of people and this was largely reflected in their differing adoption rates of the new high yielding varieties as apparent in Chapter 4, p.179.

Adequate fertilizer application and a reliable source of water emerge yet again in the second section as variables for a significant part of the variation in yield. In addition to these,

Diagram to show the variables which appear to have a significant effect on the yield.

Based on the results of the crop cutting samples.



..... Possible indirect relationship.

(.001) Level of significance of relationship.

—————> Statistically significant relationship with direction indicated.

-----> Possible causal relationship, not statistically significant.

▭ Variables which appear to have a very highly significant effect on yield.

Source: Field work for the Wheat Study - March 1972.

Fig.7.15.

the crop sample results have shown the quality of the seed which is sown is of great importance. It may seem an obvious necessity to sow seed capable of germination, but the importance of selecting well formed grains of wheat from the harvest, specifically for seed is not a feature which has been given much emphasis in extension literature. It is only mentioned briefly in an edition of the 'package of practices' published for the Punjab (26). A similar set of rules was not available for Uttar Pradesh. The farmers involved in the questionnaire survey who had received instruction on new techniques in wheat farming from local extension workers appeared to ignore the practice of sorting their seed. It was reflected in the low germination or plant survival rate in comparison with absurdly high seed rates (Fig.7.12), and is clearly a factor which could have had a significant effect on the wheat yield. It is not possible to use the non-parametric partial and multiple correlation techniques to try to isolate the effects of each and all of the independent variables, because some of these which appear to be of greatest significance are nominally scaled, and this is too low a level of measurement for the test to be carried out successfully. Caste, education level and the source of irrigation were recorded in nominal scale only. As the degree of explanation of the variation in the wheat yield cannot be reduced to a single correlation coefficient, the conclusion will have to remain at the level of the model in Fig.7.15. This diagram shows the most significant relationship between the independent variables and the yield. Inter-relationships between these so called 'independent' variables are also marked so that indirect relationships are not omitted although their extent cannot be quantified in sufficient detail.

Referring back to the introductory paragraph of this chapter, it has been shown that there is more to assessing the success of the high yielding varieties than an estimate of the number of participants in the programme. Having examined in some detail the methods farmers are using and their potential relationships with yield, the claims of the major null hypothesis (Chapter 2. p59), that farmers are not fully realising the potential of their new high yielding varieties, cannot be rejected. Yields are on average below the capabilities of the new varieties, but one cannot attribute this entirely to the inadequacy of material inputs. Much work still needs to be done in this area by the extension services to help the farmers to accept and understand the differences in the life cycle patterns of the new high yielding varieties from the traditionally grown wheat.

CHAPTER 8.

Some problems facing the farmer in obtaining credit and material inputs for his farm.

Sources of capital inputs available to the cultivator.

8.1. Introduction.

The new wheat varieties may have been adopted very readily by almost every farmer in the study area (Fig.4.2), but the same cannot be said for the new farming techniques necessary for the new seeds (Fig.6.17). The farmer appears to have modified his approach to wheat cultivation, but not sufficiently to optimize yields, and he is often criticised for not applying sufficient water and fertilizer to his fields. Just what proportion of the inputs which he needs are within his reach, however, has yet to be considered. Earlier chapters have shown that the farmers of the study area were at least aware of many of the different farming techniques required by the new high yielding varieties, but one complaint about the 'new technology' was common. The cultivators appreciated that their input levels were often low and gave as their main reason for this situation, the inadequacy of supplies of inputs when they were needed most. The problems associated with the supply of irrigation water have been considered in Chapter 7.3. Supplies of fertilizer are apparently insufficient and farmers of the study area had often been unable to obtain a particular type of fertilizer and had to use whatever substitutes, if any, were available. According to Schwartz (1974)(1), fertilizer is in such short supply in India that a large part of the chemical fertilizer market has been cornered by the black market, so creating severe problems for the cultivators.

The purpose of this chapter is to look in some detail at

the sources of the various material inputs which are available to the farmers of the study area, and to see what use is made of them. We have so far attributed all inadequacies in new farming techniques to the inability or slowness of the farmer to adapt to a new routine. In this chapter a different angle has been examined. If the necessary materials are in short supply and so unavailable to the farmer, there would be an automatic limitation to the quantity of material inputs that he could apply to his fields; and this situation would be beyond the control of the cultivator. As Bulandshahr was incorporated into the High Yielding Varieties Programme by becoming a member of the Areas Programme in 1970 (2), supplies of material inputs to the district should in theory, be assured and so should be sufficient for the needs of the farmer. In this chapter, the dependence by the farmer on government suppliers as opposed to private dealers will be considered. The Indian farmer has little or no family capital and so is always in need of credit, either of cash or of the material inputs. This chapter will be divided into three sections. The first will examine the opportunities which are theoretically open to the farmer for the provision of credit and material supplies. The main lending sources in the study area are co-operative agencies, the government agricultural department and finally private merchants.

The second part of the chapter takes a more practical aspect and examines just how far such 'theoretical' sources of credit and material inputs are available to the farmer. The data for this section of the chapter were compiled from the information obtained from farmers involved in the study. In the formal questionnaire surveys held in March and June 1972, farmers were asked where they

obtained their supplies of credit and material inputs necessary for their farms (Appendix 2.). The reasons for their choice were so diverse that by classifying and coding the information, many individual reasons would have been 'lost', so explanations of their decisions were recorded informally during conversations with the cultivators. It was clear from the field work that the farmers of the Wheat Study area were not over enthusiastic about receiving loans of cash or kind from government sources, and particularly from co-operative agencies.

In theory, government organized credit societies, in particular the co-operative system, should be capable of supplying farmers' needs. The third section of this chapter attempts to look at conditions more from the point of view of co-operatives and other credit societies. They are facing numerous problems, particularly in Uttar Pradesh, and the difficulties of credit societies and the effect on the farmer will be examined to try to see whether or not his complaints about co-operative credit and non-credit societies are justifiable.

Much of the information for this chapter has been derived from informal discussions in the field with farmers of the Wheat Study area, with local village level workers, local co-operative officers, the Bulandshahr Block Development Officer and from Reserve Bank and State Reports on co-operatives in India, and in the individual states. Much information has also been drawn from unpublished material circulated by the State Co-operative organizations, the central body, to the individual districts of the state. In contrast to chapters 4,5,6 and 7, discussion was

conducted at a far more general level, though reference to detail within the Wheat Study area is made wherever possible. Descriptive material forms the body of this chapter and there is relatively little precise numerical data which can be used for predicting conditions beyond the boundaries of the present study either over time or in space. The information collected from these sources however, did provide a clear insight into the problems both the cultivator and the credit society were facing, a picture which could not have been presented through a pre-coded questionnaire of the sort used in the study. Rural credit in India is a topic in itself, and for this particular study, qualitative material was of great value in providing background information and for answering numerous questions relating to the availability of credit and material goods within the study area.

8.2. Government organised sources of credit and material goods available to the farmer.

Government policy aims to equalise the opportunities open to all farmers in India by making credit and material goods available for agricultural purposes. At present, lack of capital and limited resources force most farmers to depend heavily on credit (3). Private merchants have been the main source of loans and of material inputs, but the complete dependence of the farmer on the private dealer leaves him open to any demands that the merchant makes, however unfair. By providing the agriculturalist with the inputs he needs at standard prices, by charging standard rates of interest, and by purchasing agricultural produce, at fixed, 'fair' prices, the government is trying to make money available to the farmer and to achieve 'growth with social justice' (4). Government organized credit societies have been in existence since the early 1900s (5), but the adoption of high yielding varieties since the mid '60s has caused demands for inputs to rise and this has provided the necessary impetus for the expansion and re-organization of the co-operative movement.

Government organized co-operatives function at four main levels - at national level, state level and at both district and village level. A description of the system will be started at the lowest tier. The village level co-operative societies are known as primary societies. These are the organizations through which the farmer himself deals. Village primary societies are usually run by the local school teacher, village head man and a group of progressive farmers or a paid outsider. Originally one primary co-operative society was located in one village, but results have shown that multi-village primary co-operative credit

and non-credit units are more successful as they are run more efficiently (6). Where several villages are involved, a secretary can be paid and hence the organization and running of the society need not be neglected. In 1972, 59.00 per cent of the cultivators of Bulandshahr district were members of primary credit and non-credit co-operative societies (7).

The concept of the multi-village credit and service co-operative has been expanded in recent years to the creation of the large scale primary society. This is the third type of primary society which exists in Bulandshahr district, and the purpose of these large scale societies is the same as the single and multi-village primary units, except that they function at an even larger scale and theoretically are more efficient. There are 20 such large scale societies in the district which cover 422 villages between them. The most common primary societies at present are the medium sized multi-village societies. There are 424 such societies which serve 1256 villages in Bulandshahr and so involve 76.63 per cent of the settlements in the district connected with the co-operative system. Very much in the minority now are the 56 single village units which serve just over three per cent of Bulandshahr's village co-operatives. According to the assistant co-operative officer in Bulandshahr, Mr.M.L.Sharma, these are the least efficient of all the primary societies within the district, and concerted efforts are being made by extension workers to merge such units into multi-village societies and hence reduce their number.

These are the three types of primary society that exist

in Bulandshahr and the next subject for discussion is the functioning of these societies. The farmer makes his claims for credit and, or fertilizer, insecticide and pesticide, and seed to his local primary society; the primary society then applies collectively to the relevant central society, the second tier of the four stage hierarchy, for the various inputs. The central societies function at district level, and there are numerous central societies. Examples of central co-operative societies to be found in Bulandshahr, are the District Co-operative Bank of which there are 16 branches which provide the farmer with credit, the District Co-operative Federation which functions in the central town for the advancement of seed, fertilizer, insecticide and pesticide, and the Land Development Banks of which there are four branches at tehsil level. These originally provided loans to farmers for the discharge of their existing debts, mainly to private merchants. Now their function has been extended to advance financial aid to the cultivators for minor irrigation schemes and for agricultural implements. Other co-operative organizations are the District Sugar Cane Society, the District Co-operative Store and the Central Co-operative Marketing Societies, at which the members pledge their farm produce. The farmer does not deal directly with most of the central societies. He applies to the primary society for his requirements along with the other cultivators and the primary society applies collectively to the relevant central societies for a block loan. The central societies of the district apply collectively to the relevant offices of the provincial co-operative federation most of which are located in the State capital at Lucknow. Advancements to the central societies are

distributed to the primary societies and so loans to the cultivator are realized.

Apart from dealings with the Land Development Bank and co-operative marketing societies, the cultivator has no connection with any other group than a local primary society. Applications for loans for minor irrigation projects and for certain farm implements are dealt with directly by the Land Development Bank. Before any advances are made, signed forms have to be obtained from the Lekhpal concerning the area of land owned and cultivated by the farmer, and the sources of irrigation which are already available to him. The Land Development Bank then assesses whether or not a cultivator is entitled to the form of minor irrigation that he requests. If he is, then he receives a loan which is repaid in arranged instalments according to his financial situation. If the loan is not repaid, the farmer's land is expropriated as a realization of his debt. The Land Development Bank is the only source of long term loan available to the cultivator as the primary co-operative societies are only entitled to give short and medium term loans, the latter extending over a period of no more than five years.

Loans are of two kinds, cash and kind; the credit limit is fixed with relation to the area of land that the cultivator holds, and loans in kind are repaid within two seasons, usually when the produce is being marketed. All cultivators who are members of primary co-operative societies are bound to pledge their wheat at the market where the quality of the crop is assessed by an official at the selling ground, and according to

the grade, the farmer receives a price for his grain, fixed by the government. Seeds advanced to the cultivator at the time of sowing are recovered at the market together with a quota of the original quantity, and cash debts on any other loans to the cultivator on fertilizer or pest control chemicals, for instance, are also recovered at this time.

The co-operative credit system was the main source of loan to the farmer in the Wheat Study area. The only other source of credit used by farmers in the study area is the Tacquavi Loan. This is given directly by the agricultural department in the form of fertilizer, seed, insecticide and pesticide. All advances on these inputs are based on the size of holding and the area to be sown with each crop. Relatively few farmers make use of Tacquavi loans. Three per cent of the sample farmers received advances of this kind from the district Agricultural Department. Farmers seemed to find that credit and material goods from co-operative societies were more easily obtained, and although a small proportion of farmers did receive Tacquavi loans, the greater number dealt with the co-operative societies, or directly with private merchants.

8.3. The relative merits of co-operative societies and private merchants as sources of credit and material goods.
The viewpoint of the cultivator.

In theory co-operation should enable farmers to get the maximum from their land, however small an area they cultivate, but in practice this is another matter. The benefits that farmers in the Wheat Study area derived from co-operative societies were examined. Co-operative societies were active in all six study villages. Sabdulpur, Kolsena and Kurwal-Banaras were members of primary societies, each of which served three villages, while the other three settlements were served by primary societies, each of which covered four villages. The associated villages were always adjacent, so communication problems were reduced to a minimum. In Chirchita and Akhtiarpur, the societies were run by official secretaries, but in the other four villages the head men of the associated villages, and in some cases the school master accepted the responsibility of collecting orders and distributing the goods to the farmers of their own particular village. The orders were combined with those from the other villages before they were forwarded to the relevant central societies. The enthusiasm for the co-operative system was even less in these four villages than it was in the other two where an official secretary at least provided the organization with a certain status.

For the most part, the farmers interviewed for the Wheat Study were apt to dismiss the primary society as a rather insignificant feature in their lives. Unlike private money-lenders, the co-operative system does not provide continuous credit. If farmers are unable to repay short term loans within the specified length of time, they are barred from any further

credit supplies until all overdues have been repaid. The cultivators involved in the enumeration were not prepared to say whether they were fully paid up members of their co-operative society or not. The accuracy of their answers was suspect, and so the proportion of farmers who obtained fertilizer through their local primary non-credit societies was taken as an indication of active membership of the co-operative. The answers were less in doubt because the cultivators were not being asked to admit whether or not they had outstanding debts. If farmers are not members of a primary society, or if they have joined the organization and have not repaid their loans, they are not entitled to buy fertilizer from any of the co-operative selling agencies. Fertilizer was selected as an indicator of membership of the local co-operative society, as the supply of chemical fertilizer to farmers is one of the main functions of service co-operatives. All-India statistics showed that in 1968, 60.00 per cent of expenditure by agricultural co-operative organizations was on chemical fertilizer. 96.00 per cent of the farmers included in the Wheat Study grew high yielding varieties of wheat and so would be heavily dependent on fertilizer. Cultivators who had made the effort to join a local co-operative society would be most likely to use it as their main supplier of fertilizer, and so this statistic seemed likely to provide a reasonably accurate estimation of the proportion of the Wheat Study farmers who were active members of their primary co-operative society.

The main farm commodities that are available from primary service societies each season are fertilizer, seeds, insecticide and pesticide. Small farm implements can be obtained through

the primary societies, while larger farm machinery, together with advances for minor irrigation schemes are provided by certain central co-operative societies. The 196 farmers enumerated for the Wheat Study were asked where they obtained these particular inputs, and as there was considerable variation among the sources upon which farmers depend, the data were analysed to see if farm input sources were related to the village group, caste, size of the area farmed or the education level of the farmer. From field observation and from analysis carried out in chapter 4, 5, 6 and 7, these variables which are among the group of 'independent' variables listed in Chapter 2. p. 66 , seemed the most likely cause of variation in the data, and these variations are discussed in the following paragraphs.

i. Fertilizer.

Farms can either buy fertilizer through the service section of their primary co-operative society, whose prices are fixed by the Department of Co-operation in the Ministry of Food, Agriculture, Community development and Co-operation, or they can buy their supplies of fertilizer from a private merchant who is apt to vary both his price and interest levels. 52.00 per cent of the Wheat Study farmers obtained their fertilizer from private sources in rabi 1971-72, while an insignificantly lower proportion of 41.00 per cent of the cultivators used their local primary societies as a source of fertilizer. Despite this statistically insignificant difference, the co-operative movement was certainly not as popular among the farmers as were the private merchants, and three important reasons for this have been isolated. First, prices of the former are fixed and so private dealers can afford to undercut.

According to the co-operative officer at Gulaothi (Fig.1.4), one of the 16 large scale societies in Bulandshahr district, the private merchant can afford to do this, as common salt, sodium bicarbonate and ash constitute a large proportion of the 'fertilizer' they sell the farmers. Extension officers working in the Gulaothi co-operative villages apparently found it a difficult task to convince the farmers that buying fertilizer from private merchants was a false economy.

Continuous credit is one facility that co-operative societies do not allow and this was the second reason for the farmers' dislike of the co-operative system. A third reason, and perhaps the most real, as it was not steeped in tradition, was that the co-operatives often did not have large, adequate supplies of goods and there was not always a guarantee that the farmer would obtain the fertilizer he wanted by registering his needs with his local primary society. Distribution of these commodities from the state level 'apex' societies may not have been in accordance with the block demands, and by the time the inputs reached the cultivator there were numerous factors which influenced whether or not he received what he had ordered. Substitution of one type of fertilizer for another was one inconvenience that several of the farmers involved in the study had to contend with. The quantity of each type of fertilizer required for the soil tends to vary, and this seemed to be a major cause of confusion to the cultivator. According to the acting Block Development Officer in Bulandshahr, Mr.B.B.Lal, extension workers had found that this confusion was in part responsible for the variation in the quantity of fertilizer

applied per unit area (8). If the primary co-operative societies do not receive all they order from the apex societies, or if certain farmers are favoured by the primary society organisers, a factor which is known to exist, but which cannot be quantified, the fertilizer has to be rationed and a farmer may be quite unable to use as much fertilizer on his field as he would like. Smaller farmers always suffered under such circumstances as their credit is never as reliable as that of the larger farmer (9).

Dependence at least to a certain extent on the private merchant is essential, and it is highly significant that 43.00 per cent of the sample farmers had to depend on a second source for their fertilizer, and of these 89.00 per cent bought their supply from private merchants. Nearly 64 per cent, the majority of farmers who bought fertilizer from their local primary society had a second source, usually the private merchant. The converse of this situation was not found to exist. Few farmers who bought their chemical fertilizer privately needed a second source, and the alternative supplier was never the co-operative society. The co-operative officer at Gulaothi explained that the fertilizer reserves of the private merchant were infinite because the mixtures were usually 'diluted' with impurities such as salt and sodium bicarbonate. The proportion of these particular compounds was known to be high, because the material deposited on the surface of the river flood plains, rich in these chemicals, was often substituted as it is indistinguishable from many types of fertilizer sold in crystal and not pellet form.

Personal preference seemed to be the only explanation for dealing with private merchants or co-operative agencies as a source of fertilizer. When the data were sub-divided according to the statistically 'independent' variables of caste, size of area farmed, the village and the education level of the farmer, the results of the Kruskal-Wallis non-parametric analysis of variance test (10) indicated that none of these variables explained any significant part of the variation in the preference for co-operative agencies or private merchants as chemical fertilizer suppliers.

ii. Seed.

Seed of the high yielding varieties of wheat and of the deshi varieties can be obtained from co-operative societies and private merchants. The farmers were once again asked where they obtained the greater part of their wheat seed for rabi 1971-72, 1970-71, and 1969-70. In each of these years the majority of the farmers obtained seed from their neighbours or from self developed stock (Chapter 6.p.263). In rabi 1971-72 the latter was by far the most important source of seed. Both co-operative societies and private selling agencies were used to a far less extent as a source of seed than a source of fertilizer. It is noteworthy that the importance of co-operative societies as seed suppliers has declined and according to the chi square test, quite significantly so, between 1969-70 and 1971-72. (chi square = 20.32 significant at 0.1% level). A similar fate has befallen private seed merchants. The decline in the proportion of farmers buying seed from private selling agencies has also shown a significant decrease between 1969-70 and 1971-72. The reason

farmers gave for the decreasing use of co-operative agencies and private seed suppliers was that stocks of the newest and most desirable seeds were short, if the primary society ever received any at all, and there was no purpose in paying interest on a loan of seed when similar home developed varieties could be sown. The most popular variety in Bulandshahr district in 1971-72, according to the District Study was Sonalika and this result was also confirmed by the detailed Wheat Study in the six Bulandshahr villages (Fig.4. 23). There was growing demand by the farmers of the area for the new triple gene varieties but these were still in very short supply, and so until seed became available as were Sonalika and Kalyansona by 1971-72, some of the wheat harvested was set aside for the following year's seed. 99 per cent of the farmers involved in the Wheat Study followed this policy and so it came as no surprise that no significant patterns and relationships were revealed between the source of wheat seed and any of the 'independent' variables.

iii. Insecticide and Pesticide.

The necessity of pest control methods is being emphasized to the farmer as the responses of the new wheat to unknown pests are unpredictable (11). The indigenous varieties had an inbuilt resistance against many pests which could affect the new varieties and so their effects cannot readily be anticipated. New types of rust, for instance, are continually appearing on the new varieties. The genetic similarity of all the new high yielding varieties makes protective measures essential against pests which could damage and destroy vast areas sown with these genetically similar plants. The large quantities of fertilizer and water which are

used give rise to dense vegetative growth and the situation is ideal for pests to breed. According to the report of the National Council for Agricultural and Economic Research (NCAER), farmers were receptive particularly to demonstration, but in the study area, they were unwilling to use pesticide as it was not always essential. Its benefits are not as apparent as are fertilizers, but according to estimates 15 per cent of the total crop is lost each year due to pest attacks, but farmers are still not convinced (12). Only nine out of 196 farmers enumerated for the Wheat Study used any form of plant protection at all; this is even below the 10 to 30 per cent of northern Indian farmers who use plant protection. Great losses are still occurring due to inadequate plant protection. The spread of rusts in the Punjab in rabi 1973-74 (13) has caused a loss of 0.5 million tonnes of the estimated wheat harvest. Losses such as this, particularly in the main wheat areas of Punjab, Haryana and Uttar Pradesh could, according to the NCAER (14) seriously affect India's food supply. In every case in the Wheat Study area, the local co-operative society was the main selling agent of pest control chemicals. This situation is predictable because the private merchant, like the cultivator, is relatively unaccustomed to the use of plant protection techniques, and as this aspect of wheat farming is still unpopular with farmers of the study area, private dealers are apt to concentrate far more on the sale of fertilizers. Some forms of insecticide can be mixed with seed before sowing, but where a sprayer is required, it can generally only be hired through the primary society. Dependence on the co-operative was complete for pest control materials, as the farmers of the study area had relatively little choice of the source of their

plant protection equipment.

Unlike the fertilizer situation, private merchants and 'middle men' were no competition for the co-operatives. Their major problem was to convince farmers of the necessity for plant protection. One can visualise strong competition arising between private merchants and co-operative societies once the use of pest control techniques are more widespread, and the situation becoming similar to that of the co-operative-private merchant struggle for the fertilizer market.

iv. Farm machinery.

Preliminary field work had shown that the farmers who used small farm implements, such as mechanical chaff cutters and threshers, usually owned them, whereas larger types of machinery were commonly hired. During the formal questionnaire survey, cultivators were asked where they had hired tractors, and also the source of loans for purchasing their smaller farm implements (Appendix 2.1.questionnaire). It was clear from chapter 6 that relatively few farmers used farm machinery. Only one of the 196 cultivators involved in the Wheat Study owned a tractor, while a mere eight farmers used tractors for ploughing. The only tractor owner cultivated the largest area of any of the farmers in the sample, and obtained his loan from the Land Development Bank. Farmers who hired tractors all did so from neighbouring cultivators. This was unexpected as the main dealers in farm machinery are Agro-Industries and the likelihood of the farmer obtaining his tractor from this source with the aid of a loan from the Land Development Bank, was high. Further discussion

with the farmers revealed that a relatively small proportion of cultivators in a village would apply to hire a tractor, and, as the procedure was lengthy and complicated, the enterprising cultivators would then loan tractors to their neighbours on a much more informal and undoubtedly profitable basis. More farmers therefore, used tractors than hired them from co-operative societies, but for the most part holdings were sufficiently small to make it just as profitable for the cultivators to use family labour and their own draught animals.

The most used small farm implements were the mechanical thresher and electric pump. These were owned by approximately nine per cent and 12 per cent of the sample farmers respectively. Clearly farm machinery was almost negligible in the farms of the study area as not one of the other farm implements noted in the questionnaire (Appendix 2.2) was owned by more than ten per cent of the sample farmers. Those farmers who did own machinery were commonly members of caste groups I and II and had farms above the mean size of 3.54 hectares for the area. The chi square test was used only in the case of the thresher and electric pump to illustrate that it was the farmers with holdings larger than the mean for the study area who owned most of the mechanical threshers and electric pumps. (Mechanical threshers, chi square = 23.84, significant at .1 per cent level; electric pump, chi square = 41.47, significant at .1 per cent level). The number of farmers using the various other forms of farm machinery were too few to be examined statistically.

All cash loans for farm machinery had reached the cultivator

either through the Land Development Bank, through Tacquavi loans via the district agricultural department or through private transactions. In several cases, loans for farm machinery had been turned down by government organized credit schemes because the holdings of the farmers concerned were not considered to be 'viable units'. There are few criteria for deciding just what constitutes a viable holding and a subjective decision on the viability of the holding made by one of the local government officials, is most probably based on the Lekhpal's recommendation. The Small Farmers' Development Associations (SFDA) co-operatives designed specifically to help the smaller farmer, who was often potentially weak in a village community (15), seemed to be quite ineffectual in the study area. For instance, grants are not given for tube well pumps to farmers whose holdings are too small or are within a 300 metre radius of a government tube well. Theoretically, these should be able to obtain all the necessary irrigation water from the government tube well; or, if beyond the influence of the government tube well, small farms will not be given grants because they cannot use a tube well to capacity and so must rely on open wells instead. Personal communication with farmers in Chirchita village (Fig.1.4.) during the harvest study, showed that the problems of obtaining regular and adequate supplies of water are extreme for cultivators with small holdings or whoever is within close range of a government tube well. The irony of the situation is that often farmers with holdings which are not considered 'viable units' are in greatest need of a grant from the Land Development Bank. Farmers have no option but to obtain credit from private merchants at interest rates that their marginal holding can hardly bear.

A holding that does not qualify for a loan is very often small in size and yet the purpose of the co-operative system as it so frequently states, is to rule out disparities between 'rich' and 'poor' in the rural landscape, and to give small farmers equal opportunities with the larger land owners. Several instances during the field work showed that this was not the case and observations are supported by Nair who states that the present policies of the government, rather than bringing equality to rural India, are increasing the gap between rich and poor (16).

v. Marketing.

Finally co-operative marketing must be considered. This has proved to be unsuccessful almost everywhere in India except in Uttar Pradesh (17). The success of marketing co-operatives within the state is attributed to the marketable surplus, particularly of wheat. Rajagopalan (1971) comments on the lack of success of marketing co-operatives in Himachal Pradesh for instance, where the marketable surplus is considerably smaller (18).

In the Bulandshahr district there are nine market centres held in the major towns to which farmers bring their harvest. The government fixes the price, Rupees 76 per quintal in 1972, for the best grade of wheat and this should enable the farmer to get a 'fair deal' at the market, according to the quality of his produce. All members of credit and service co-operatives are bound to belong to the marketing society as this is one method of collecting dues. Farmers who do not belong to any form of co-operative organization can still take advantage of

the co-operative marketing system. Theoretically, the farmer can get a 'fair' price for his crop, but in practice, many farmers do not obtain maximum benefit from the system. The queues at the market are long and farmers may have to wait two to three days before their harvest is assessed and weighed. According to the local acting Block Development Officer, Mr.B.B. Lal, the farmers are often not prepared to wait, and so sell their wheat to private merchants for less than they would receive from the co-operative. These private sales are also a means of evading loan repayment. In practice, the farmer is worse off than he could have been as any further dealings with the co-operative society will be severely hindered because of over dues.

For purposes of security, payment for the crop at the market is by cheque and not in cash. Further information from the acting Block Development Officer at Bulandshahr, Mr.B.B.Lal, told of the farmers' suspicion of cheques. Many preferred to sell their crop at a lower price to the private dealer in order to receive 'ready cash'. The dealer can afford to do this as he then sells the grain through co-operative marketing channels and obtains the government recommended price. The efforts of government organizations to eliminate private dealers cannot hope to succeed if the cultivator himself has no desire to see justice done.

Despondency with government organized credit and non-credit societies, which was found to exist in the very limited study area, is certainly not reflected in statistics published for the whole of India. Co-operatives have been functioning in India

Achievements of the Co-operative Programme at the All-India level.

| | <u>1955-56</u> | <u>1961-62</u> | <u>1968-69</u> | <u>1969-70.</u> Provisional values. |
|--|----------------|----------------|----------------|---|
| 1. Value of agricultural produce marketed by co-operatives. | 53.00 | 174.70 | 588.50 | 599.00 Rs.crores |
| 2. Value of fertilizers distributed by co-operatives. | NA | 32.30 | 200.80 | 232.49 Rs.crores |
| 3. Value of seeds and inputs distributed by co-operatives. | NA | 7.74 | 30.10 | 32.81 Rs.crores |
| 4. Value of consumer goods distributed by co-operatives in small areas. | NA | 23.00 | 242.70 | 225.69 Rs.crores |
| 5. Number of co-operative sugar factories in production. | 3 | 34 | 62 | 70 |
| 6. Number of co-operative processing units organized / assisted. | NA | 561 | 1596 | 1617 cumulative |
| 7. Storage capacity available with the co-operative. | NA | 7.50 | 25.80 | 27.00 cumulative lakh tonnes |

Source: Government of India, Ministry of Agriculture.
Department of Co-operation October 1971.
Report of the Expert Committee on the National
Co-operative Development Corporation, Delhi, p.43.

Fig.8.1.

since 1904 (19), and although they have achieved 'striking progress' in many parts of India; Tamil Nadu, Kerala, Gujarat, Maharashtra and Punjab being notable examples (20), their levels of success in Uttar Pradesh have not been quite so outstanding(21). Statistics for the country as a whole show a consistent rise in the strength and effect of co-operative societies since the introduction of the National Co-operative Development Corporation (NCDC) in 1955-56. Fig.8.1. shows some of the 'achievements' cited by the corporation at the all India level.

8.4. Problems facing co-operatives as suppliers of credit and agricultural inputs.

Uttar Pradesh does not reflect the successes of the National Co-operative Development Corporation (NCDC) statistics for the whole of India. A recent unpublished report entitled 'The failure of the co-operatives in Uttar Pradesh and possible methods of reorganizing the system' has been circulated to all the districts of the state. Its title alone is sufficient to indicate that the farmers have not wholly exaggerated the situation with respect to co-operatives. The report claims that the 60.00 per cent of the population of Uttar Pradesh who are supposed to be members of the co-operative societies according to cumulative district statistics, is illusory (22). Recent estimates indicate that the proportion of active members in the state is nearer 36.00 per cent. The fake figure has arisen because it includes every member who has ever joined the co-operative society within the state, but it fails to account for nearly half the borrowers who have failed to repay their overdues and so are no longer 'active' members of co-operative societies. The report estimates that membership of co-operatives in Uttar Pradesh is about 4.00 per cent below the all India average, and in addition, the average loan per member is Rupees 117 in the state, 51.10 per cent of the all India mean of Rupees 239.

Many of the central co-operative banks in Uttar Pradesh have 'eroded their capacity to obtain financial assistance from the Reserve Bank of India', by allowing heavy over dues to accumulate. These over dues increased from Rupees 24.30 crores¹

1. one crore = ten millions.

to Rupees 35.40 crores during 1970-71, and formed 47.70 per cent of loans outstanding in the state (23). In 31 of the 55 banks in Uttar Pradesh, over-dues were greater than 50.00 per cent of the loans outstanding against the societies by June 1971, the end of the co-operative year (24). Farmers complain about the inefficiency of co-operative organizations, but it was a common feature that money borrowed from co-operative societies was often used for social and not always for agricultural purposes, and consequently debts could not be met. Consequently, many of the banks from which cultivators had received loans were quite unable to repay their dues to the apex banks by the specified dates. Unless there is a higher level of feed back into the system, the programme cannot hope to succeed and the report demands that

' the government should cause coercive action to be taken against defaulters to affiliated societies with the utmost speed, with concentration first on the larger borrower.' (25)

Just what the government can do if the cultivator refuses to repay over-dues is debatable. It would probably cost the co-operative system more to take legal action against a cultivator than to write off his debts. Cultivators argue that they would be willing to continue their dealings with co-operative societies if credit was continuous, and they could repay loans over a longer period of time as they do with private merchants. The purpose of the co-operative system is to give the poorer farmers in particular a 'fair deal', and unless interest rates were raised to match those of the private merchants, an impractical situation, co-operatives could not hope to survive if they allowed the farmer continuous credit.

As a result of growing over-dues in the state and inadequate re-organizational effort, the number of primary agricultural credit societies has fallen since 1969-70 (Fig.8.2). According to the report this situation has not arisen because primary societies have merged, but because previously inefficient organizations have been abandoned.

Diagram to show the decline in the number of primary agricultural credit societies in Uttar Pradesh.

| | |
|----------------|--------|
| 30th June 1969 | 26,397 |
| 30th June 1970 | 26,301 |
| 30th June 1971 | 26,200 |

Source: 'Failure of the Co-operative system and remedial action', from the 'Master Plan for Accelerated Development of Agricultural Credit Production through Co-operation in Uttar Pradesh'. Unpublished paper. U.P.Dept. of Co-operation.

Fig.8.2.

The state co-operative organization aimed to create 1000 viable societies by 1971-72, but achievements have been low and by November 1971, only 94 societies which could be classed as viable units, had been formed.

One of the major problems of co-operatives is their organization, particularly at the level of the primary societies. With the scheme to convert the original single village co-operatives into multi-village units, the need for better organization is increasing. Of the 26.20 primary societies in Uttar Pradesh in 1972, only 3.91 per cent had full time, paid secretaries, 14.39 per cent of the remainder were official part time organizers.

The majority had none. It seemed that the amateur approach to organizing co-operative societies at the lowest but most important level was bound to generate apathy in the majority of cases. The concept of co-operation is still quite new to many farmers, and until the purpose and benefits of the system becomes apparent, the present attitude of the cultivator is bound to remain. Too often responsibility for collecting orders and distributing goods was shared by too many people in a village, and was unsatisfactory. These observations in the field were reflected by the Ministry of Agriculture (1971) when it was emphasized that the most viable units were those which were organized and run 'properly' and not merely created and forgotten (26).

The co-operative system has had to face a series of problems during the past decade, each one greater than the last, and the cumulative effect has done much to suppress the success of the scheme. First, the concept of co-operation was entirely new to the farmers, even though government organized credit systems have been in existence since the beginning of the century, they have not been widespread. The purpose of the co-operative system is

' that the villagers should come together, pool their resources and work with intimate knowledge of one another as well as a sense of mutual obligation..'

and so eliminate disparities between rich and poor.(27). If co-operatives are to succeed, the emphasis must be placed on the need for a 'sense of mutual obligation'. Unfortunately, the prevailing desire is to obtain as much as possible from the system with the minimum feed back, particularly with reference to loan repayment. Farmers interviewed for the Wheat Study

seemed to have no perception of the consequences of their mounting over-dues on the co-operative system.

Lack of understanding of what the co-operative is, and what it is trying to do, has done much to halt its progress in India. In Uttar Pradesh where the system is faring particularly badly, about one third of the farmers are active members and therefore seem to appreciate the workings of the movement. There are still many who are very wary of the system and prefer to deal with private merchants.

The introduction of the new high yielding varieties in the mid 1960s, gave a boost to the co-operative scheme. The input requirements of the new plants are high (28), and the need for seed, fertilizer, insecticide, pesticide and material and financial aid for minor irrigation projects gave the system scope for growth as a supplier of these inputs. One cannot help but feel that this period of growth will be short lived, if it is not drawing to a close already. Demands for inputs have been so high that the system has not been able to cope adequately with this period of greater activity. Storage space for goods in central and primary societies was limited, supplies were inadequate to meet demands, particularly of fertilizer, small farm machinery and credit. Insufficient staffing led to delayed deliveries to both central and primary societies. Farmers sometimes did not receive their inputs till the end of the crop season when it was too late. Wrong orders were delivered and financial assistance from the government to the co-operatives was not always forthcoming to the required extent. Prolonged

delays in adjusting the amounts due to the co-operatives on account of transport and storage costs, for instance, have further affected their efficiency according to the National Co-operative Development Corporation report (29).

8.5. Conclusion.

It is not surprising that farmers are disillusioned with the co-operative system. The inability of the co-operatives to provide their agricultural requirements (Ch.8.p.368), has done much to destroy any sense of 'mutual obligation' between organization and farmer. Shortages always tend to ruin any policies of 'give and take', inherent in co-operation.

In addition to a lack of understanding of the scheme by farmers, and poor organization within the co-operative system, conditions must be further aggravated by rising prices and shortages of raw materials, on a world scale. Shortage of fertilizer has already had an effect on India's 1973-74 wheat crop, and one feels that production of necessary inputs will not significantly increase in India during the next three to four years, a period which may be crucial, as there is an impending world food shortage (30).

The failure of co-operatives in Uttar Pradesh is closely connected with the failure of farmers to understand the system, and to take an active part in it, with the purpose of improving agricultural conditions and assisting the weaker sections of the community. According to Taimni (31), the co-operative movement which was intended as a 'shield for the weak' has turned into a 'sword for the strong'.

CHAPTER 9

An assessment of the value of new dwarf wheat to the farmer.

9.1. Introduction.

The adoption of the new high yielding varieties has caused many changes both in the pattern of wheat farming and in the entire farming routine (Chapter 6). These changes which have been widespread are not restricted to the study area (1,2,3,4), and have occurred far more rapidly than many believed possible (5,6). For such changes to have occurred, the cultivator must have felt that certain forms of agricultural innovation would be worth his while, and it is the value of the new wheat varieties to the farmer which this chapter examines. The wheat yields of almost 36 per cent of the farmers in the study area were well above the 1971 district mean yields of 14.48 quintals per hectare (7), the most recent statistic available for comparison with the study data. The new varieties of wheat are highly responsive to additional inputs of water and fertilizer in particular (8), and on account of their needs the cost of cultivation of the crop is high. In this chapter the value of the wheat harvest of each farmer in the study area is compared with the costs of fertilizer, water, insecticide, pesticide, seed, labour and mechanisation that he incurred in rabi 1971-72.

Extensive adoption of the new varieties has shown that it must be to the cultivators' advantage to sow the new wheat varieties. If it was not, levels of their adoption would be much lower. This was confirmed by George and Singh (1971)(9), who showed that the use of non-conventional techniques and methods is a function of the cost-benefit ratio, so if the farmer is using them, they must prove worth while. As the specific aim of the

Cost of inputs incurred by three arbitrarily selected farmers.

| | Sample farmer <u>1</u> | Sample farmer <u>2</u> | Sample farmer <u>3</u> | |
|--|------------------------------|------------------------------|------------------------------|---------|
| Seed | | | | |
| Fertilizer | 112 | 315 | 360 | Rupees. |
| Irrigation | 38 | | 200 | |
| Pesticide & Insecticide | | | | |
| Labour | 60 | 50 | | |
| Machinery: purchase/hire running costs | | | | |
| Total cost of inputs -Rs. | <u>210</u> | <u>365</u> | <u>560</u> | |

Fig.9.1a.

Calculation of inputs and outputs per unit area of the above
three arbitrarily selected farmers.

INPUTS.

| Sample farmers | Total input cost Rupees | ÷ | area of new wheat bighas | = | mean input cost per unit area. Rs. per bigha. |
|-------------------|-------------------------------|---|--------------------------------|---|---|
| 1. | 210 | / | 8 | = | 26.25 |
| 2. | 365 | / | 18 | = | 20.27 |
| 3. | 560 | / | 30 | = | 18.66 |

OUTPUTS.

| Sample farmers | Total yield X Quintals | X | Mean selling price/ Q. Rupees | ÷ | Area of new wheat bighas | = | Output per unit area. Rs. per bigha. |
|-------------------|---------------------------|---|-------------------------------------|---|--------------------------------|---|--|
| 1. | (10 | X | 75) | / | 8 | = | 93.75 |
| 2. | (30 | X | 74) | / | 18 | = | 123.33 |
| 3. | (82 | X | 74) | / | 30 | = | 202.26 |

Source: Field work for the Wheat Study - March 1972.

Fig.9.1b.

thesis was to examine the changes that have taken place in selected wheat farming patterns and practices (Chapter 2.p. 59), information was collected on certain variables which would act as indicators of change. These seven variables listed above are of great importance in this context and owing to the limited resources of the study, the list could not be extended to satisfy fully the demands of an input-output analysis. Field observation showed that the first six of these seven variables were essential to new wheat farming. A study of the economic viability of new wheat would not have been valid if based on these data (10), so as a compromise, a 'balance sheet'¹ has been drawn up to compare the cost of the seven selected inputs listed on Fig.9.1a., with harvest returns per unit area. These seven inputs should be used by most wheat growers. Fig.9.1 a and b. illustrates the form of the 'balance sheet' constructed for each farmer involved in the Wheat Study. The values of several variables were difficult to estimate, so the methods of calculating the values of these individual variables used in the 'balance sheet' will be discussed next.

1. Quotation marks have been used for the term 'balance sheet' to indicate its non-conventional form.

9.2. A discussion of the methods and problems involved in assessing the cost of selected inputs to the wheat farmer.

i. Fertilizer.

There are two main sources from which the farmer can obtain his fertilizer, one is from a local primary co-operative society, and the second is from a private merchant. Details of the availability of fertilizer are considered in Chapter 8. In the questionnaire each cultivator was asked what quantity of each type of chemical fertilizer he had used in his fields in rabi 1971-72 (Appendix 2.1), and on this basis, the cost of fertilizer incurred by each farmer was estimated. The cost of fertilizer applied to the new varieties was calculated from approximate prices quoted by the Principal of the Agricultural College, Bulandshahr, and confirmed by the fixed prices quoted in 'Fertilizer Statistics', 1971-72 (11). As financial resources for the Wheat Study were limited, it was impossible to carry out a further questionnaire to collect such detailed information directly from the cultivators. For practical purposes, the original questionnaire could not be lengthened, as the enumeration of each farmer lasted approximately two and a half hours, and beyond this the farmers were not prepared to be helpful.

A set of questions relating to costs was included in the pilot study questionnaire, but was discarded as the questions gave the farmers a great deal of difficulty, and it was felt that the information could be estimated with acceptable accuracy. Unfortunately prices paid to private merchants for fertilizer could not be obtained, so all estimates were based on one price list. Informal conversations with the cultivators and local officials, however, confirmed that extreme shortages of fertilizer

within the district had encouraged the development of a black market, so making prices paid privately comparable with those paid to co-operative societies (12). Data relating to prices from private merchants were unavailable, but it was felt that if costs of fertilizer were estimated on the basis of the most recent government price list, a close approximation to the truth would probably be obtained and would be of value to the Wheat Study.

Organic manure was also used in the study area in addition to chemical fertilizers, but according to the farmers its usage had declined considerably since the introduction of the high yielding varieties and chemical fertilizers. These results correspond with the findings of Chawdhari et al. (1969), who have shown that in IADP districts where the spread of high yielding varieties is encouraged, it is the inorganic fertilizers which are used in the main (13). Although the District Study results suggest that green manure is commonly used in the district (14), this was not found to be the case in the study area. Only 31 per cent of the farmers who were enumerated for the Wheat Study used organic manures in comparison with 44 per cent of the District Study farmers in rabi 1971-72. As the proportion was relatively low, and the problems associated with costing the manure were high, the estimate of its cost was omitted from the analysis, and the study concentrated solely on the costs of chemical fertilizer to the cultivator. Field discussions with the farmers showed that they considered the use of green manure an old fashioned technique, and not in keeping with the more modern approach to farming to which they had recently been introduced, and for which they had been encouraged to use chemical fertilizers.

2. Irrigation water, seeds and farm machinery.

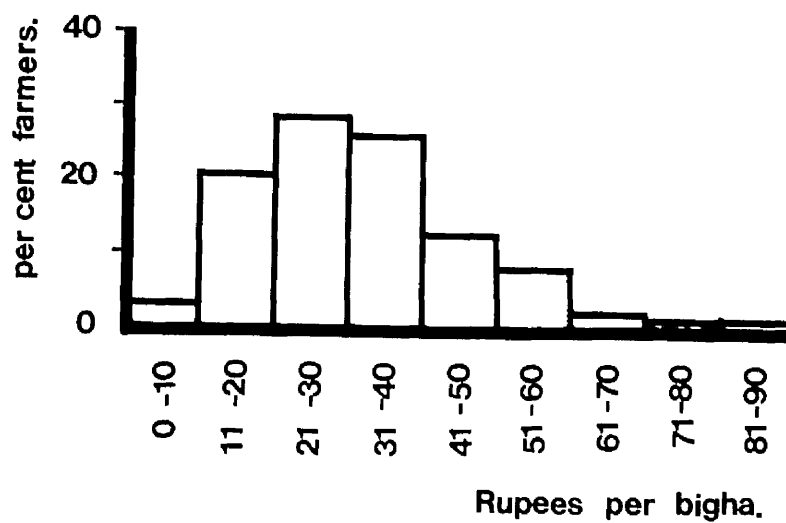
Estimation of irrigation water costs would have led to gross inaccuracies, so each cultivator was asked for the relevant information in the questionnaire (Appendix 2.1). Canal users are either billed on estimates of their needs or, if they are tube well users, on their electricity or diesel consumption. There seemed to be few problems over this question in the pilot study and so it was included in the formal questionnaire survey. Similarly, information on the cost of seeds and rental of farm machinery (Appendix 2.1) were also obtained from the questionnaire, as it was extremely difficult to estimate the value of these with any accuracy. Interest rates on all these inputs varied around ten per cent, according to the source of loan, but, without a further questionnaire, it was impossible to discover their actual cost to each farmer. This was not a practical possibility in this study, and rather than assess the value of the interest inaccurately, it has been omitted, and the initial cost of each of the selected inputs has been used instead.

3. Labour.

Labour is a significant factor in the cost of wheat cultivation, but most labour costs are incurred at harvest time. Permanent labour was not a major cost and only 14 per cent of the 196 farmers enumerated for the study employed permanent farm workers. The questionnaire material was not sufficiently detailed to estimate that proportion of the cost of a permanent labourer devoted to wheat farming. As a result, the cost of temporary labour employed at the time of harvest only, was included in the analysis.

Traditionally, harvest labourers used to be, and are still generally, paid in kind. They would receive a proportion, usually eight or ten bundles of wheat out of every hundred they harvested as their wages. Since the new varieties of wheat have become popular, owner farmers felt that wages of ten per cent of their crop are too high, as the absolute quantity of wheat received by the employee at this rate has increased so significantly. During the field work, one became aware of the conflict between employers who wanted to pay their temporary labour in cash, and harvesters who wanted to be paid, as they always had been, in kind. In the study area wage rates of eight or ten per cent were most common, but some of the farmers gave their workers as little as five per cent of their wheat harvest, because they felt that in absolute terms this was quite sufficient.

VALUE OF SELECTED INPUTS PER UNIT AREA
OF 'NEW' WHEAT.



Source: Field work for the Wheat Study-March 1972.

Fig. 9.2

9.3. A discussion of the 'balance sheet' of inputs and outputs compiled for wheat farmers in the study area.

i. The Inputs.

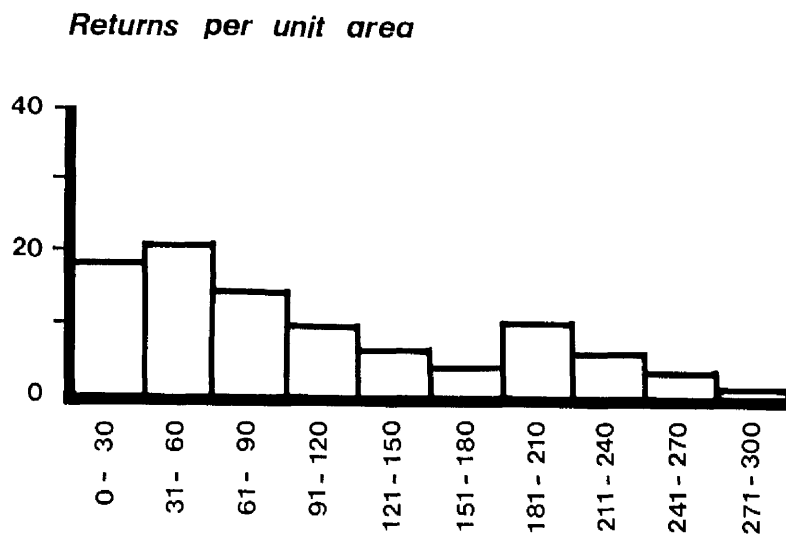
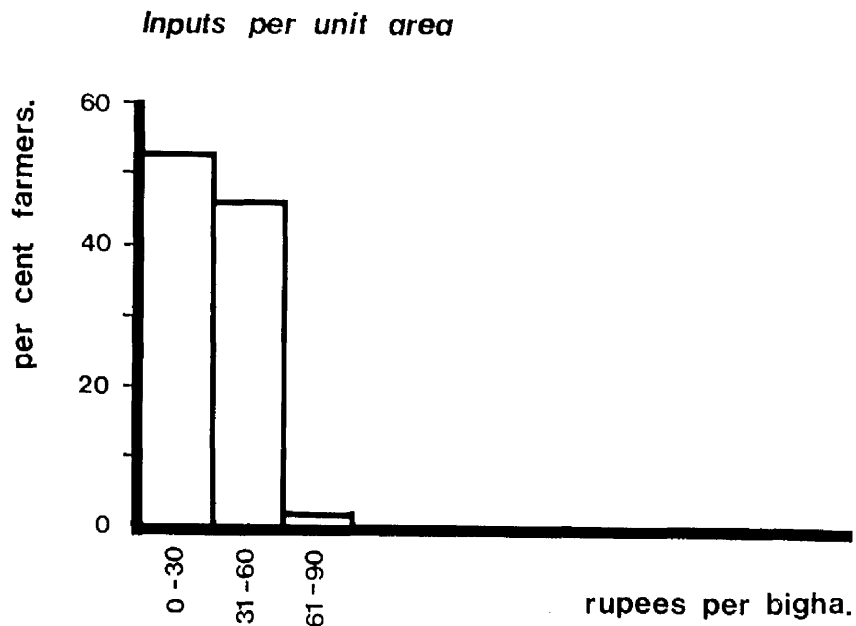
Observation during the field work and information from the farmers and the acting BDO of Bulandshahr, Mr.B.B.Lal, confirmed that fertilizer, water, insecticide, pesticide, seeds, farm machinery and labour were the major requirements of wheat farming and that the cost of at least some of these were met by every cultivator. The estimated cost of these seven variables was summed for each farmer, and his total expenditure per unit area of wheat, based on these selected inputs, was calculated. Fig.9.2 is a frequency diagram illustrating the results. The mode of the distribution falls within the 21 to 30 Rupees per bigha grouping, (259.35 - 370.50 Rupees per hectare). 55 per cent of the cultivators in the sample spent between Rs.21 and Rs.40 per bigha (Rs.259.35 per hectare and Rs.494.00 per hectare), on their new wheat. Apart from a few isolated cases where inputs were markedly higher, the distribution clusters around the mode.

A similar study by Kahlon, Miglani and Singh (1971) (15), in Ferozepur district, Punjab, showed that inputs into irrigated dwarf wheat were approximately Rs.64 per bigha, nearly double the value of the inputs in the study area. It is appreciated that any additional inputs considered in the Ferozepur study, such as, family labour and machinery running costs which were omitted from the Wheat Study, could have been responsible in part, for the higher input costs incurred in Ferozepur. Detailed field work, however, showed that the variables considered in the Wheat Study were the main inputs used by the farmers and these constituted the greater part of the annual input cost of the

wheat crop. This implied that input costs were arranged differently in the study area, and were probably lower than in Punjab, on account of the higher level of mechanisation in Ferozepur, and the greater dependence on family labour in Bulandshahr. For many farmers in the study area, input levels similar to those recorded in the Ferozepur study (16) would have been impossible, for without a reliable credit system, they did not have the capital to invest in their farms. Discussions with the cultivators confirmed the findings of George and Singh (1971)(17), that the farmers were investing as much as they possibly could in their fields, always in anticipation of higher returns.

Research by Malenbaum (1971)(18), Mukherjee (1970)(19), Chowdhury (1970)(20) and Allan and Rosing (1973)(21), has shown that input levels per unit area in 'smaller' farms are usually greater than on 'larger' farms, as cultivation is more intensive on small farms. The data from the study area were divided according to the modified log scale, which has been used throughout this dissertation (Chapter 4.p.158), but the Kruskal-Wallis two way analysis of variance test showed that there was no significant difference between input levels per unit area in these farm size groups. The data were again tested to see if farmers who cultivated areas above the mean size for the sample of 43.72 bighas (3.54 ha.), differed in the value of their inputs per unit area from farmers with holdings below the mean size. The Kruskal-Wallis test was used and again no significant result was obtained, implying that any variation was probably not due to farm size, and could have been the result of chance.

SELECTED INPUTS AND RETURNS PER UNIT AREA FROM
'NEW' WHEAT.



Source: Field work for the Wheat Study - March 1972 .

Fig.9.3

Other variables which have been the cause of patterns in the data in earlier chapters were introduced to see if an explanation of variation in the data could be found. In addition to the size of the area farmed, the data were divided according to the caste, the education level, and the village identity of the farmer. In every case the Kruskal-Wallis test showed that it was impossible that these variables determined any pattern which might exist in the data. None of the results was statistically significant.

Input values could have been influenced by personal choice and by factors not studied in this thesis which directly affected the financial situation of the family. Standing debits for instance, on which data were scarce, could well influence the quantity of capital available for investment. Equally, the number of dependents on the cultivated area could affect how intensively a piece of land was farmed. Questions relating to the number of dependents on the farm were included in the questionnaire (Appendix 2.1), but unfortunately people who were not totally dependent on the farm were not isolated owing to an error in the enumeration, and so the data were of little value when input levels were compared with the number of people supported by the farm.

The input costs met by each farmer were balanced against the total value of the harvest from the new high yielding varieties of wheat. At the local wholesale market where surplus grain was sold, the price of wheat was fixed according to the quality of the grain. The method of assessment has been discussed in Chapter 8. In the second questionnaire, each farmer was asked

what price he had received for the greater part of his new wheat and from this, the total value of his new wheat crop was estimated.

The returns per unit area of land were estimated using these data together with the calculated input costs. Greater variation was found to exist in these data than in the input values, and a comparison of the inputs and returns per unit area shown in Fig.9.3 illustrates this clearly. Returns ranged from Rs.12.64 per bigha (Rs.156.10 per hectare), to Rs.266.55 per bigha (Rs.3291.89 per hectare), with a mean value of Rs.101.21 per bigha (Rs.1249.9 per hectare). The Spearman rank correlation test showed that there was no significant relationship between the total value of the selected inputs and the returns per unit area. Initial research hypotheses on which the chapter is based, assumed that some relationship between inputs and outputs would be apparent. If one could be more certain about the quality of the data used in this chapter, these results would be very interesting as the volume of inputs appear to bear no relationship to the outputs.

As the study was not intended specifically as an input, output analysis of wheat farming, it was not possible to include every input used by the cultivator and, furthermore, the resources of the project did not allow for it. The variables which were examined however, were selected aspects of wheat farming, of interest in earlier chapters as indicators of change from traditional to modern techniques, and although they did represent many essential inputs into wheat cultivation, the list was far from exhaustive. For instance, more detailed information on labour

inputs throughout the season could not be obtained for the Wheat Study, neither was sufficient information available on the cost and quality of fertilizer and seed obtained from private sources. Data relating to the maintenance of farm animals and farm machinery were yet another group of inputs which had to be omitted from the 'balance sheet'. In addition to these inputs, it would also have been interesting to see if, where and how much grain was lost after the harvest, as there could be no indication of this from the data collected for the Wheat Study. These omissions from the 'balance sheet' are yet another possible reason for the absence of patterns in the relationships between inputs and outputs of wheat farming examined in this chapter.

In Chapter 7.p.323 , we saw that yields showed little relationship to inputs because much depended, amongst other things, on the quality of the seed that was sown. If good quality seed was sown and treated correctly, then a high germination and plant survival rate could be expected, and if all environmental needs of the plant continued to be met, a high yield of grain per unit area could be expected. If on the other hand a large proportion of the seed sown was sterile, then regardless of inputs, high yields per unit area would be unobtainable. With such reasoning, it is possible to see how outputs in one season may relate to the inputs of a previous season, and not necessarily to inputs of the one season during which the study was carried out. Unfortunately, the quality of the seed could not be examined as field work for the Wheat Study began in March, approximately four months after the seed had been sown.

It was felt that this complete absence of pattern in the data might be due to analysis of the material at the wrong scale, and that relationships between inputs and outputs might emerge if the data were analysed at a more detailed level. The next step was therefore to use the variables caste, education level of the farmer, size of the area farmed, and the village identity of the farmer to test for any pattern in the value of the returns per unit area of the study farmers.

Bearing in mind the results of the Wheat Study so far, what could one predict? In Chapter 6, p. 286 we saw that the 'higher' caste, 'larger' cultivators used more fertilizer on their fields than did farmers with 'smaller' holdings, but when the total value of selected inputs per unit area was calculated earlier in this Chapter, we also saw (p.394) that there was no significant difference in the investment levels, based on a total of seven selected inputs, between 'large' and 'small' farmers. Results of similar studies which have shown investment to be higher on smaller holdings, Sen (1968)(22), Sen (1970)(23), Rani (1971)(24), have concluded that productivity per unit area was higher on small farms than on those operating at a large scale, while net profit was progressively higher per unit area as holdings increased in size.

It is not surprising therefore that in the Wheat Study area where no significant difference was found in the investment level per unit area, the Kruskal-Wallis test showed, that no significant difference was apparent between the per unit area returns of farmers who cultivated areas either greater or smaller than the mean holding

size in the study area. Similar results were obtained with the non-parametric two way analysis of variance, when the same hypothesis was tested using farm size groups divided according to the modified log scale used throughout the thesis (p.158). If predictions that levels of investment are related to output, then it comes as no surprise that in the Wheat Study area there is no significant difference between the output from the wheat fields of cultivators with either large or small holdings.

As the Wheat Study was not designed specifically to measure the output from wheat fields in relation to certain selected inputs, it is possible that critical inputs may have been omitted from the analysis. One such factor for instance, could be farm management. If the farm has long been successful, it is likely that management of the holding has been good and so, in addition to the measurement of farm size, an assessment of managerial quality would be valuable to the study. Unfortunately the financial resources which were available limited the scope of the Wheat Study, so data were not collected on the quality of farm management either past or present. Neither was much detailed information collected on the permanent and/or temporary labour employed on the farms, another factor which could well have influenced farm output. The enthusiasm of farm workers and the care taken in their work would probably depend on a number of factors including whether or not they were family members, and on the quality of supervision. This together with the number of workers per unit area could also affect the output.

The number of people that the farm has to support is another

variable which could not be given due consideration owing to an error in the collection of the data. It was not clear to what extent members of a family were dependent on the farm, and to what extent on alternative sources. This could not be adequately measured by the questionnaire which was used, and the limited resources of the study prevented further work in this direction. It is felt that if data had been available on such aspects as these, the results of this chapter might have been far more interesting and conclusive. They are an obvious omission from the study and must be mentioned to indicate some of the possible reasons for the unexplained variation in the results of the statistical tests.

As both caste and education level of the farmer are related to the size of the area farmed, it was predictable that there would be no significant relationship between either the caste or education level of the farmer, and output from the wheat fields. This was confirmed by the Kruskal-Wallis test. Analysis of the data according to village identity also gave insignificant results, so implying that the variation which existed in the data could not be explained by these variables.

In a further attempt to explain the variation in the data, the input values of fertilizer and irrigation water per unit area were related to the calculated output values. The mean cost per unit area to the farmer of each of these two variables, fertilizer and irrigation water, was calculated. The Kruskal-Wallis test then showed that farmers spending more than the average of Rs.14.94 per bigha (Rs.184.51 per hectare) on fertilizer, obtained an output

significantly higher at the 0.1 per cent level of probability ($H = 65.62$). A similar result occurred with the cost of irrigation water. Cultivators who had spent more than the mean cost per unit area, also received significantly higher outputs from their fields ($H = 45.72$). It is interesting that fertilizer expenses of most farmers are approximately double the cost of their irrigation water.

Unfortunately no explanation could be reached to show why certain farmers spent more on fertilizer and water than did others. Greater expenditure on fertilizer and irrigation per unit area, did not correspond with farmers of higher caste groups, or of higher education level or with those who cultivated larger holdings. None of the groups of variables used throughout this thesis as 'independent' variables (Chapter 2.p. 66) showed any significant relationship with either the cost of fertilizer or of water. The case of fertilizer is interesting because, in earlier parts of the analysis, the higher caste farmers with their larger holdings applied larger quantities per unit area of their main fertilizer to their fields. Quantity and cost of chemical fertilizer however, are unrelated. For instance, farmers in the study area required approximately 415 kg. of CAN per hectare, and if urea was used instead of CAN, the necessary quantity was much smaller, 240 kg. per hectare in similar soil conditions, although the cost may have been as high if not higher than the total cost of CAN. The fertilizer data were re-examined and as anticipated, the smaller farmers tended to use the newer and more costly fertilizer no less than the larger, higher caste farmers. As a result of this the cost of fertilizer per unit area in the

small farms was not significantly lower than in the larger holdings and hence, it is possible to see how these two apparently contradictory results can co-exist.

The variables used in this study may not have explained why certain farmers used higher input levels than did others. Personal choice may have been the cause of this. The scope of the study has to be limited, and so further material to clarify a number of features is not available. As predicted however, the farmers whose expenditure on their wheat was above the mean of the sample, had higher returns from their fields.

These results are not as conclusive as they might be, but conclusions are always tentative when dealing with the inputs and outputs of an agricultural system, and especially when this is a peasant farming system. The number of additional variables which may be of great significance could not be assessed adequately in the field and they have not been accommodated in the analysis. It is therefore probably safest to leave the results in their present semi-complete form.

ii. Disposal of the harvest and estimation of returns from the new wheat.

The value of the returns calculated per unit area is not a concept familiar to the farm operators of Bulandshahr district. Not all the harvest is translated into currency, and a significant proportion of the crop may be retained for seed and consumption. In the questionnaire each farmer was asked both how and where he disposed of his harvest. There are three main outlets for the wheat harvest. A certain proportion of the crop is retained for food, some may be kept for seed while the rest, if any remains, is sold.

Every farmer retained wheat for food. The quantity that was kept varied according to the requirements of the farmer, his family and his dependents. 91 per cent retained some of the harvest for seed for the following year. As with wheat reserved for food, there was no predictable pattern in the data. Much seemed to depend on the farmer's personal choice as to whether he kept some of his own seed, exchanged seed with his neighbours or bought new seed the following season.

The proportion of the wheat harvest that was sold also showed considerable variation. It ranged from 0 to 100 per cent. Analysis of the proportions kept for food and seed showed no significant patterns, but when the proportion of the harvest that was sold was analysed according to the Kruskal-Wallis test, the result showed that the larger farmers with holdings above the mean for the study area, of 3.54 hectares, sold significantly greater proportions of their wheat than did the smaller cultivators. ($H = 3746$). Clearly, this was not an unexpected result.

Co-linear variables of caste and education level of the farmers gave similarly significant results. Farmers of caste groups I and II (Chapter 2. p. 154) sold significantly greater proportions of their harvest than did the members of caste group III ($H = 89.50$). These farmers did own the larger farms and so the result was anticipated. Many of these higher caste farmers who cultivate the larger holdings have also been educated above primary school level, and so the Kruskal-Wallis test also showed that they sold significantly greater proportions of their harvest than did the rest. The argument in Chapter 6 was that caste was the major influencing factor, but in this case it seemed to have more of an indirect than a direct influence on the proportion of the wheat harvest that was sold. Farm size seemed the most important variable in this case. With a small farm and very often a family of five or more members, a farmer had no surplus of wheat for sale while the larger farmers invariably produced more than they could consume themselves.

9.4. Conclusion.

The purpose of the High Yielding Varieties Programme coupled with government planning is to raise the agricultural output from the land and give the 'smaller' farmer an equal opportunity with the larger. By producing more per unit area, the smaller farmers of the sample with less than 20 bighas (1.62 hectares) for example, still find that their surpluses are too small to market and so a subsistence economy makes it difficult for them to become involved in the co-operative system where the repayment of loans depends largely on the farmer selling his surplus wheat at the wholesale market. Farmers whose wheat yields are just sufficient for their own domestic needs and who have no surplus for sale and for the repayment of loans on fertilizer, seed, insecticide, pesticide and any other inputs are immediately barred from the co-operative lending system if they are unable to repay their loans within the set period of time. Without further help and encouragement many of these small farmers are never able to repay their debts and so derive no benefit from government credit organizations. In the study area none of the farmers seemed to benefit from the Small Farmers Development Agencies (SFDA)(25), which are supposed to be particularly active in the High Yielding Varieties Programme districts. The new varieties and their associated technology are often put out of the reach of these farmers, even though one of the main policies of co-operation is to assist the smaller farmer.

From the results of this study, it is difficult to assess what value has been derived as a result of these changes from traditional farming methods. Data are not available to compare the returns per unit area from deshi wheat fields, but even if

a family does not have more money to spend, the data have shown that the yields of a significant proportion of the farmers are above average for the district and the country as a whole, and so speak highly for the potential of the new seeds which are being sown. Discussions in the field showed that even farmers with the smallest holdings were reaping more wheat from the same unit area, and though they might not have land enough to produce a marketable surplus, their quantity of wheat for home consumption had increased since they had adopted the new varieties.

There is much evidence (Byres 1972)(26) to show that the larger farmers are benefiting greatly from the introduction of the new varieties. The new methods and seed have not modified the conventional pattern of small farms providing higher returns per hectare than larger farms. At the same time the general raising of yields has advantaged the farmers with larger holdings, as any surpluses which they were accustomed to raise have been increased, and this group of large farmers is able therefore, to participate further in the 'new technology' which is capital and credit demanding.

Returning to the initial question - have the changes that farmers have made been worth while - the answer in the study area, is yes. Food shortages in India are the cause of great concern, and if food problems are to be alleviated, every possible method of increasing agricultural production must be explored. The Indian farmer is all too often 'condemned for being unwilling' to modify his traditional ways, but even if the new high yielding varieties serve no further purpose, they have introduced new ideas

to the cultivator and have demonstrated the benefits that can be achieved by change, an essential factor for the progress towards higher production so necessary in agriculture.

CHAPTER 10.Conclusions and possible directions for extending the study.

The purpose of this conclusion is to draw together the main elements of the thesis, and to examine their implications. In Chapters 4 and 5, we saw that the new wheat varieties had been eagerly adopted since their introduction to the study area, and all the results indicated that the innovators in the sample were farmers of 'higher' caste status, such as Jats, Brahmins, Rajputs, and to some extent Gujars. These cultivators introduced to their villages, new methods of farming which were subsequently adopted to a greater or lesser degree by the remaining cultivators. By 1972, some of the new wheat was being sown by almost every farmer enumerated for the Wheat Study.

Having established that the new varieties had been widely adopted in the study area, it was possible to progress to the main aim of the thesis, which was to examine the methods farmers were using for growing their new wheat, to see if they had modified their traditional approach to wheat farming, and finally to see how closely they were approaching the new farming systems consistent with the new 'scientific' agriculture. Information on how to farm the high yielding varieties was set out by the Department of Agriculture in the 'package of practices', a detailed list of instructions on wheat farming relevant to a particular area, in this case, Bulandshahr district.

Results showed that farmers were applying far more water and fertilizer to their new wheat fields than they had done in the past, and it was well known among the farming communities

we visited that the application of sufficient quantities of these particular inputs resulted in high yields, the main reason for farming the dwarf wheat varieties. Adoption of the new wheat has necessitated a change in the seasonal farming routine, and cultivators seemed to be coping well with what must have been one of the most difficult adjustments to make. Owing to the shorter life cycle of the new varieties, the seeds have to be sown later and harvested earlier, and the need for frequent and regular applications of water and fertilizer is essential. Although a few farmers continued to sow their new wheat early to capitalize on the last monsoon rains, as they always had done, the majority were prepared to sow their seed at the time which best suited the new seed, that is, the first two weeks of November.

Farmers did tend to pay less attention to other aspects of 'new' wheat farming, such as the use of insecticides and pesticides as results from these were not always evident, and the attitude was that one might as well take the risk that the crop would not be damaged by pests. The new farming technology is often symbolized by sophisticated farming machinery, but there was little evidence of change from tradition in this direction. Machines are not essential to the success of the new varieties in the study area as they are labour saving devices and labour is plentiful.

Patterns emerging from these data were always of the same nature. If significant variations did exist in the use of selected techniques, it was always the 'higher' caste, better educated, 'larger' farmers who adopted the new approach.

The next step in the thesis was to test predictions based on the results of Chapter 6, that farmers who used more modern, apparently preferable techniques, harvested the higher yields. This aspect of the study was explored by the use of a second questionnaire carried out in July 1972, well after the harvest and all transactions connected with it had been completed. The range of yields was enormous, and surprisingly, predictions that the higher caste Jat, Brahmin and Rajput farmers would harvest the highest yields proved incorrect. The only 'independent' variable which seemed to have a significant influence on the yield was the fertilizer input, and although the members of caste groups I and II used more fertilizer than did the third caste group, they did not all do so. The relationship between fertilizer input and yield was not perfect either, and as the yield was dependent on numerous other variables, one can see why the predicted caste-yield relationship might not exist.

Questionnaire data are perpetually in doubt as they are dependent on the integrity and recall of the farmer, so a second assessment of the wheat yield was based on crop samples taken from the fields of farmers enumerated for the Wheat Study (Fig.1.4). Details of this survey conducted in one village only, Chirchita, have been fully discussed in Chapter 7. It was hoped that yield estimates based on the crop cutting samples could be compared with the questionnaire results, and in addition provide material for a study on a more detailed scale.

The crop cutting samples, however, were extremely small. Three, one metre quadrats were cut from each of 35 plots in

Chirchita, and in every case the respective farmers had been enumerated for the Wheat Study. The samples were transported from the field to the Indian Agricultural Research Institute, Delhi, where they were analysed by the wheat breeding section. The height of the plants per quadrat was measured, the number of plants, the number and size of heads of grain per plant, and the total yield from each quadrat, were some of the many variables which were measured.

As the farmers who owned these fields had been enumerated for the Wheat Study, the possibility of selected relationships between the inputs to the wheat field and the results of the crop cutting samples were explored. A significant result was obtained between the estimated yield and the fertilizer input, but perhaps the most important and interesting relationship was found when the number of seed sown per unit area was compared with the plant germination or survival rate, as estimated from the field samples.

The seed rate seemed to be very high compared with the number of plants per unit area, and we were eagerly assured by the cultivators when this point was pursued, that the quality of the seed was often so low that more than double the quantity had to be sown in order to ensure that the germination rate was sufficiently high to lead ultimately to a fair wheat yield. This implied that the relationship between inputs and outputs from a wheat field extends beyond a single season. Low and irregular inputs in one rabi season could lead to the production of wheat which may be sterile. Regardless of the input level

in the following rabi, much of the seed may be incapable of germination, and so yields may be automatically lower than they need, and so the spiral can continue to descend. It is on account of this that the government advocates a renewal of seed, from a reliable source, every four years, and not a mere exchange with a neighbour, which is what the majority of cultivators tend to do.

Further work at the field scale would have been of great value to the Wheat Study, but unfortunately field work commenced in March 1972, well after the seed had been sown, and it was not possible to examine the quality of the seed the farmers were sowing in particular fields, and to record the details of fertilizer, irrigation water, insecticide and pesticide used at a field scale.

There was scope for a great deal more study on the loss of grain at and after harvest time. As these losses have a direct effect on the availability of wheat for food, the value of the high yielding varieties is considerably reduced, if grain is lost on account of poor harvesting and storage methods. Great care is taken in the transport of the grain from the fields, and after it has been cut, the women spend days in the fields picking up the ears of wheat, and where possible, the individual grains which had fallen off during harvesting. At threshing time too, great care is taken to ensure that no grain is left behind on the threshing floor, and one could go on to argue that even if the wheat is not threshed completely, very little is lost as the straw is cut up for chaff and fed to the animals, so it is not lost to the system. The greatest losses of the harvest grain were observed to be

during the storage period. If the grain was not completely dry, mould developed on the grains in the high temperatures and spoilt them. Alternatively, rats proved a great problem to the farmer, and losses due to destruction by these two factors were perhaps of the greatest importance. With detailed study one could compare the quantity of grain harvested in a season, and stored for the farmer's use, with the amount he had actually used by the following season. It is not possible to quantify the loss without research, but observation did indicate that a considerable part of the harvest was being lost, and this is of great importance in a situation where food is in such short supply. This would have required observation for an entire season, and unfortunately the time and resources of the study did not allow for this. It would be an interesting point to pursue, however.

Returning to the Wheat Study, an informal discussion with farmers in the field indicated that they were aware that inputs were inadequate, and hence yields were often lower than they should have been. The availability of selected inputs to the farmers was examined in Chapter 8 by considering the various sources from which cultivators obtained their inputs. A hierarchy of government suppliers has come into being since the mid 60s in an attempt to supply the farmer with all his necessary inputs of both cash and material goods. An investigation of these various government supplies operating through local co-operative societies, revealed that theoretically, farmers could obtain all their requirements for wheat farming by placing orders with their primary co-operative society which served several villages. The primary society applied collectively to the secondary society.

which functions at district level and which then places orders for the entire district with the head offices at Lucknow. In practice this system was not as efficient as it seemed. Many farmers did not appear to understand the principles of co-operation, as the level of loans which were not re-paid, was high and particularly so, in Uttar Pradesh. This meant that co-operatives could not be self supporting, and were in debt. In addition, shortage at the national level meant that goods needed by the primary co-operative societies were in short supply and this resulted in black markets, and hence, unfair distribution at the level of the primary society. Doubtless, similar practices could be identified higher up the hierarchy as well. Under these circumstances it was only the cultivators in a better financial position who could afford the necessary inputs. These were the 'larger' farmers, often of 'higher' caste, who, it was shown earlier, tend to have higher input levels, particularly of fertilizer which, next to irrigation water, is the most necessary input. In a situation such as this, it is clear that the smaller farmer must be at a disadvantage, especially since he derived little if any benefit from the Small Farmers Development Agencies, created especially for his protection.

The results of Chapter 8 confirmed earlier thoughts that the approach to wheat farming was not entirely controlled by the farmers ability to comprehend a new system. Many were quite aware of the new farming techniques, and few were reluctant to change from traditional methods. Their main problem was that inputs were not readily available, and even if they were, the credit system was not sufficiently well developed so their efforts to obtain the necessary inputs would still have been limited.

It would have proved interesting to follow the attempts of a few selected cultivators to obtain fertilizer, for example, from the various sources available to them. Every farmer to whom we spoke had tried the primary co-operative society first, just in case there was any hope of getting fertilizer on credit. The smaller farmers were usually turned away to find an alternative source, but the larger farmers who, in a financially superior position were potentially more rewarding customers, were able to buy their fertilizer through the co-operative. The small farmer had no alternative but to deal with the private merchant. Credit rates were therefore higher and there was no quality guarantee given with the fertilizer. Analysis of the contents of fertilizer bought from the government and private sources would have been a valuable addition to the study, as according to local agriculturists, the percentage purity of the fertilizer is known to be low. In these circumstances the small farmer is likely to be further disadvantaged.

From the results of Chapter 9 it was clear that 'small' farmers did little more than break even by the end of the rabi 1972, and without any form of credit they could not have progressed so far with the high yielding varieties, even though returns per unit area may not have proved higher on 'larger' farms, in absolute terms these 'larger' farmers are in a financially superior position to the 'smaller' cultivators, and so have some capital at the end of a season to invest in fertilizer, insecticides and pesticides for the following season, and perhaps small farm machinery, such as mechanical threshers and chaff cutters.

By the end of the field work, and certainly by the time the data had been analysed, one was very aware of the need for more detailed research, often at the individual field scale. This does not reduce the value of the Wheat Study, for without such information at this more generalised level, one could not be aware of relevant questions which would emerge from it, and which could only be answered by investigation at a more detailed level. Despite their tendencies to accentuate disparities between large and small, and hence rich and poor farmers, the high yielding varieties of wheat have demonstrated their potential in India, and within seven years of their introduction have done much to promote interest and research into Indian agriculture. In their earlier stages in particular, the new varieties did much to boost the morale of cultivator and agriculturist alike, but one cannot help wonder whether or not these hopes were based on unstable foundations.

The new varieties have also shown that in parts of India, albeit the more 'progressive' parts, the farmers are quite prepared to abandon their traditional methods in favour of a new approach to farming. One could argue that cultivators of Bulandshahr are an unrepresentative sample in this case, as they are more accustomed to innovation than are most Indian farmers who are so often believed to be 'tied to tradition' (1). Bulandshahr has experienced and benefited from change. First, in the form of the canal system which provided many cultivators with some safeguard against the severe climate, and so they were able to attempt new farming methods with some degree of confidence. Since the canal era the Ganga-Jamuna doab, an area of great

agricultural potential, and one of the most productive regions in the wheat growing plains of northern India (Chapter 3.p.29), has felt the impact of new improved indigenous varieties of wheat and other cereals that have been produced by wheat breeders since the turn of the century. Since agriculture assumed a place of importance in the government five year plans, the districts of the doab have received more than their share of extension effort as a result of schemes such as the IADP, IAAP and the most recent HYVP. The policy of IADP was deliberately designed to promote agricultural advancement in the well endowed areas, such as the doab, at first, and gradually to extend the extension services from these centres (2). It could therefore be argued that even in the remotest parts of Bulandshahr, for example, the farmer has not been very far from examples of change. Possibly all one can conclude is that within areas such as the dogb which have always been of importance as agricultural lands in Uttar Pradesh, the traditional Indian farmer has shown himself to be adaptable to modern techniques.

The implications of these changes in agriculture.

The farmers in the study area have readily adopted the new wheat, but what are the trends for the future ? The level of inputs required by the new wheat is extremely high and has to be maintained if their potential yields are to be harvested. If fertilizer and water, for example, the two most important inputs are in short supply, yields will fall. Shortly after the mid '60s when the number of adopters was growing in the study area, demands for fertilizer and to a certain extent, water, could be met. As demand has increased, supplies have not been able to

meet them and in 1972, when the study was carried out, it was felt that a turning point had come. It seemed that production could not continue to increase as it had done since 1965-66, and that a fall in yield and hence production, was inevitable on account of the extreme shortage of inputs. Unfortunately, data on wheat yields and production of Bulandshahr district are not available for 1972-73 or 1973-74, but in the two successive years after the study, the climate has been unfavourable.

Winter rains have failed during the main growing stage of the wheat, and this together with acute shortages of other much needed material inputs, has made life extremely difficult for the farmer. Shortages of fertilizer have been reported due to the scarcity of raw materials necessary for their production; steel for the production of fertilizer plant, and farm machinery is in short supply; in addition, supplies of power for machinery, such as fertilizer plant, or electric pumps for tube wells, have been severely limited. The power problem has been aggravated by recent fuel shortages and by subsequent increases in the price of oil since the oil crisis early in 1974 (3).

According to Schwarz (1974)(4), rising inflation within the last two years has crippled the public distribution system which, in theory, enabled every cultivator to buy his farm inputs and to market his outputs at fair fixed prices. Shortages in material inputs in particular, have encouraged black markets, and under such conditions it is the 'larger' and usually wealthier cultivator who has the advantage over his smaller competitors. In this way a spread of the new varieties is likely to further increase the gap between 'rich' and 'poor' which they were

initially intended to narrow (5)(6). The tendency for this to happen was apparent in the study area.

Wheat production of the smaller farmer is likely to fall if the present situation continues; and if the quality of his seed falls as a result of low and irregular inputs, as the results of Chapter 7 suggest they might, then yields are liable to fall to below the levels of deshi wheat. Many farmers have stopped growing deshi and it is fast becoming scarce. This in itself is a danger to wheat farmers, because the vast genetic variability of deshi wheat, on which wheat breeders depend for their resources, is rapidly being lost. On the social side, the small subsistence farmer who depends entirely on his farm for food is likely to suffer severely with a food shortage as a result of continued crop failures, but what is worse is, that he will lose even more by spending as large a proportion of his income on inputs to his wheat field, in anticipation of higher returns.

In the long term these same economic and social problems would worsen, and in addition a change in the physical environment could well become apparent. Problems of soil erosion are always close at hand, particularly on the land which does not have a dense plant cover. Constant use of fertilizer, insecticide and pesticide could have an adverse effect on plant growth in the future. There is scope for further work in this area to examine the potential effects of these chemicals both on the productivity of the soil and on their indirect effects on man. Some of the chemicals used widely in India such as DDT, have been severely restricted in their use in the western world, and with unlimited

use could be extremely harmful to the environment. If there was a trend to re-introduce traditional varieties of crops, the physical environment may have altered so much that traditional crops could no longer be grown in the traditional way. This however, is mere speculation and is not based on any research. If problems such as these did arise, they would automatically be reflected by economic and social conditions.

What options are open to the farmers of Bulandshahr ?

As shortages of essential inputs have been responsible for lowering the potential of the high yielding varieties in less than a decade since their introduction to India (7), would it not be preferable to concentrate less on encouraging the spread of these high yielding varieties and to concentrate more research on improving and on developing less 'demanding' strains of the indigenous varieties. Before the Mexican wheats with their enormous yield potentials became popular, Indian wheat breeders were gradually raising the yield capabilities of indigenous varieties. From 1953-54 to 1965-66, food grain production in India increased at nearly two and a half per cent a year and this was entirely due to improvements in indigenous strains of wheat (8). The major problem which confronted the cultivator and the wheat breeder was that the thin-stemmed deshi wheat was apt to lodge if the weight of the grain became too great and so yields could not be raised even further. The development of the dwarfing genes, however, solved this problem (9)(10).

One could argue that applying smaller quantities of essential inputs to the high yielding varieties would have the same result as sowing wheat with lower yield potentials, but

unfortunately this is not necessarily so. The indigenous wheat varieties could produce good quality grains capable of germination with a relatively low level of inputs. If however, inputs to the new varieties are low, the seed produced is often of poor quality; it may well be shrivelled and sterile. This field observation was confirmed by Mr.V.S.Mathur, of the wheat breeding section at the Indian Agricultural Research Institute, Delhi. The proportion of sterile seed in a harvest can adversely affect yields in successive years as was suggested from the results of Chapter 7 (p.346), where extremely high seed rates seemed to be necessary for the production of an 'average' yield.

Even if 95 per cent of the cultivators in the district were sowing new varieties in 1971-72 (11), the district wheat yield statistics (12) (Fig.3.17) imply that harvests are not as good as they should be throughout the district, and so the use of lower yielding varieties which demand less in the way of material inputs would probably deprive the cultivator of no extra grain. According to the results of Chapter 7 some of the wheat yields in the study area were well above the mean for the district of 14.48 quintals per hectare, but it has always been maintained that the study area is situated in an agriculturally advanced part of Bulandshahr, and so not suitable as a basis for generalization about the entire district. This was confirmed by the District Study (1972)(13).

Interest in improving the indigenous varieties, however, has diminished markedly within the past decade. After Mexican wheat was introduced to India, all research was directed towards

breeding the dwarf varieties to suit the Indian environment and the Indian palate. Conversations with wheat breeders at IARI showed that it was no longer fashionable to concentrate research on improving indigenous varieties if one was a wheat breeder, or to grow the deshi wheats if a farmer. At the time of the Wheat Study clearly the only form of research which provoked any interest was related to increasing the yield potential of the dwarf varieties. The most recent hybrids available to the farmer were the triple gene varieties, and in order to produce their potentially high yields, they required even more fertilizer, irrigation water and plant protection chemicals than did their predecessors. When the government is unable to supply farmers in one of the Programme districts with adequate inputs, what will be the situation when the adoption rate of the new varieties rises still further, and so do their input requirements ?

The new technology associated with the Green Revolution has not yet been successfully assimilated in India, as it depends so heavily on the use of material inputs which are not widely available in India. A change in the approach to increasing agricultural output therefore seems necessary. Allen (1974)(14) suggests that rather than introducing new technologies to cope with the growing needs of food, agriculturalists should concentrate more on improving traditional techniques which could have long term benefits, rather than act as temporary boosts to the system.

Allen cites the example of the cropping system which traditionally involved inter cropping. Wheat was often sown

together with barley, gram, mustard or jai. Green Revolution enthusiasts denounce this as the 'wrong' approach, as soil nutrients shared by two crops cannot possibly lead to higher yields. The alternative to this old agricultural system was relay cropping of pure stands of crops, and so farmers were urged to give up their traditional methods. Many farmers in the study area have stopped sowing a second crop with their wheat (Chapter 5), but the adoption of relay cropping has not been widespread. In consequence, if wheat yields are not high, the farmer does not have a second crop on which to depend. Recent research (15) has shown that the overall productivity from the land can be increased by inter cropping, and attempts are now being made to re-introduce the farmer to his former system in which he is encouraged to use carefully chosen crop combinations. There was an attempt to re-introduce inter cropping in the study area, but the farmers were confused about it, and were wary of returning to a system which resembled traditional farming. Once again the results of the experiment were not followed up as the study resources did not allow for it. This is a field where further research could be directed, as it explores the possibility of using existing resources to the full instead of the present policy of dependence on an unreliable supply of foreign material goods.

Scarcity of material inputs in addition to unfavourable climatic conditions point towards food shortages, as early as 1974-75, which according to Schwarz will be as bad as the worst famine years of the sixties (16). Such threats of famine are even more acute now than in the previous decade, for then the

grain surpluses of the United States of America were available to come to India's aid. In this year, 1974, however, after a drought in the United States and unfavourable climatic conditions in Asia (17), there have been no such surpluses and the hope of self-sufficiency in India seems even further away than before.

The new varieties of wheat have not made India self sufficient in grain as was initially hoped and expected. Poor wheat harvests in 1973 and 1974 have made it necessary to import approximately ten million tons of grain (18). Even so the new varieties cannot be deemed a failure as they have demonstrated their potential and have done much to arrest the complacency of both peasant cultivator and agricultural research worker after the poor years of the last decade (19), when morale was low. Enthusiasm for the new wheat in particular, has been overwhelming, and if the supply of essential inputs could be maintained, the future of wheat farming would be more certain and the prospect of increasing agricultural output would be more hopeful than it is at present. According to Khusro (1969)

"...while not everything that is theoretically feasible can readily be put into practice, nothing should be put into practice that is not theoretically feasible." (20)

As demands for inputs for the high yielding varieties continue to grow, and as there seems to be no immediate hope of supplies meeting these demands, one cannot help but wonder if the policy to increase agricultural output in India, by encouraging the spread of the high yielding varieties and their associated technology is not both a theoretical and hence a practical impossibility under the prevailing conditions.

APPENDIX.

1. Sampling procedure prior to collection of data in the field.

1.1. Introduction.

The decision to examine certain aspects of wheat farming in Bulandshahr district of Uttar Pradesh, was determined by the location and nature of the District Study 1972 (Fig.1.1). Part of this study which was devoted to agricultural innovation showed that the new high yielding varieties of wheat had been adopted throughout the district. As wheat is the main crop and the staple food of the people in Bulandshahr, this seemed to justify a project which concentrated on wheat farming alone.

1.2. Selection of the study area.

The District Study (1972) drew its sample from the whole of Bulandshahr, but the sample area of the Wheat Study was far smaller, (approximately 750 sq.km.), due to the limited forms of transport, time and finances which were available.

A 'circle' of radius 16 km. (10 miles) around Bulandshahr formed the arbitrary boundary of the Wheat Study area. Bicycles were the only form of transport available, so the distance to the sample villages could not be unreasonable. If the enumerators had further to travel, it was unlikely that sufficient field work could be carried out each day. Sampling from a larger area would not have proved satisfactory, as the length of time devoted to the collection of field material could not have been extended owing to limited finances.

Any further data collection, particularly involving secondary

source material would also be facilitated if the sample area fell within both the administrative boundaries of Bulandshahr Tehsil and Bulandshahr Block Development Area. Nearly all the records of these administrative areas were available in the district town. The 'circle' around the district town fulfilled these requirements too, and so provided further justification for limiting the size of the study area.

1.3. Selection of study villages.

1. Choice of the number of villages for study.

Six villages were sampled within the study area around Bulandshahr district town. The financial resources of the project were the main determining factor in this case. Five enumerators were employed to carry out the field work, and as one village was to be sampled on one day, this was equal to 30 man days, or one enumerator for approximately one month, which was as much as resources would allow. In addition to this it was convenient to sample six villages on six consecutive days, as no problems involving sampling at different times in the year would then be encountered.

2. Choice of the six sample villages.

As the sample area was located near the main town of the district, and as there was no part of it which seemed to be remote from any of the major lines of communication, it was likely that the study area contained a biased sample of the villages of the district. Little could be done about this, and it is appreciated that this is one of the major downfalls of subjective sampling.

The District Census Handbook of 1961¹ records all the inhabited villages of the district according to tehsil and Block; and characteristics such as size, in terms of both population and area, are also recorded. In order to involve six villages which were in some way typical of the villages of the district, the variable of village population size was held constant. A frequency diagram of village populations for the entire district was plotted. The modal point of the frequency diagram was taken to represent the most frequently occurring village population size. In 1961 this was about 1000 people.

An arbitrary limit was placed on either side of the modal point, and so six villages with populations of between 900 and 1100 were randomly selected from the settlements of Bulandshahr tehsil and Bulandshahr Block, which were listed in the District Census Handbook (1961)². If the random numbers did not provide villages both within the sample area and with populations of between 900 and 1100 they were discarded, and sampling continued. The first six villages which fulfilled the requirements of the sampling scheme became the six sample villages of the study.

It must be added that stratification according to village area could also have been carried out, either with or in place of the variable of village population. It was a subjective decision to compare groups of people of similar size, and allow the area of the villages to vary.

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1. Census of India, 1961, District Census Handbook, Bulandshahr District, U.P., 1965 Lucknow.
 2. Ibid.

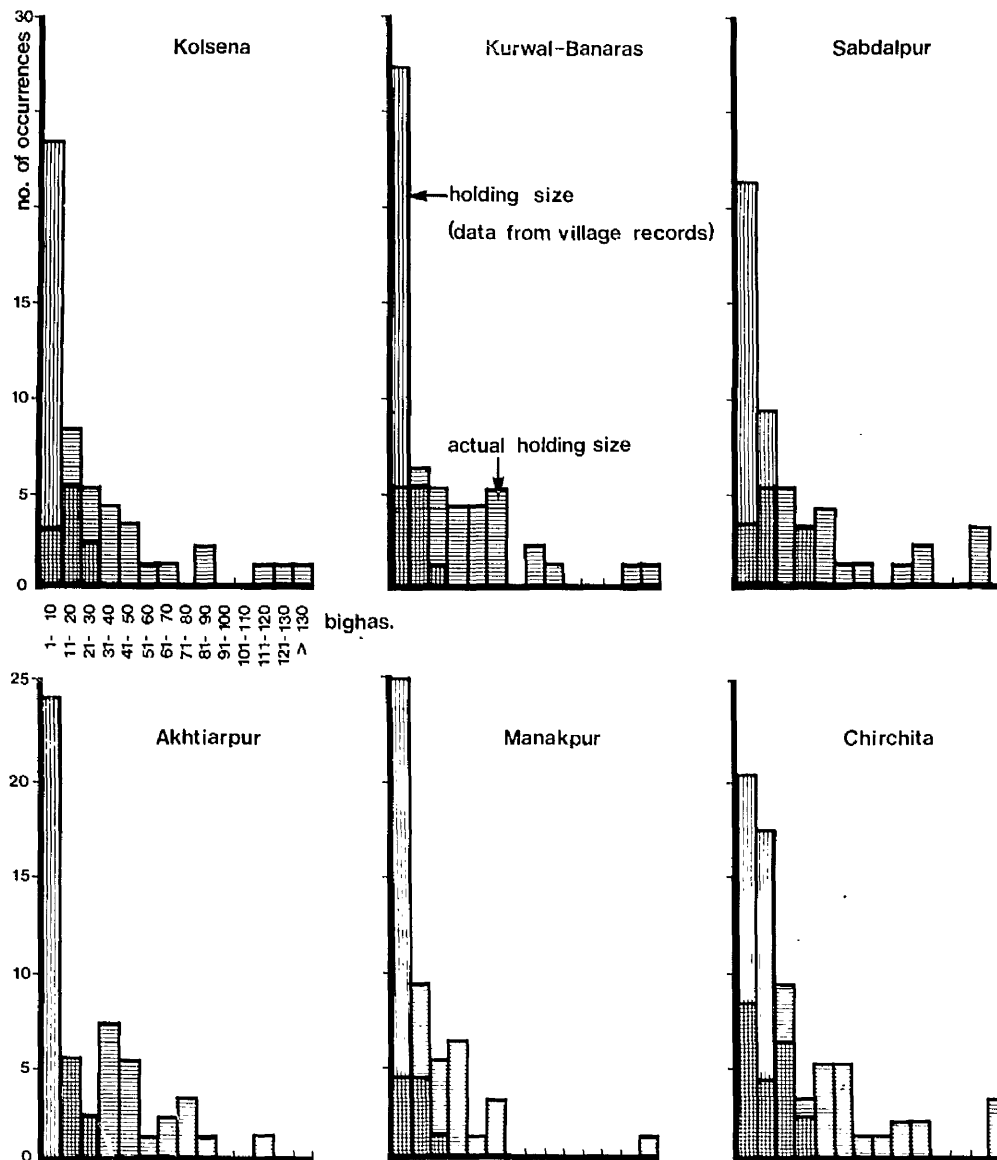
1.4. Selection of farmers within each village.

A minimum number of 30 farmers was sampled by questionnaire from each village. This arbitrary figure was chosen because it was possible to enumerate 30-45 farmers in one day, a sample which was adequately large to test with parametric statistical techniques if required.

Initially an attempt was made to stratify the sample of farmers according to holding size. A brief period of observation in the field indicated that farm size could be a significant control variable. A list of farmers in each village, together with their holding size was obtained from the lekhpal, of the village. Farm size was quite arbitrarily divided into the following groups: 0-5, 6-10, 11-15, 16-20, 21-30, 31 bighas and above. From observation it had appeared that there was an emphasis on the smaller size farms, and this is to some extent represented in the groupings above.

It was more difficult than was anticipated to obtain a stratified random sample from the list, or chhitta, compiled by the lekhpal. The record showed that the majority of the farmers had one bigha, little more, and often just a fraction of this unit. On account of this, it was always impossible to obtain an equal number of farmers within each farm size grouping. The sampling scheme had to be modified. 45 farmers were selected randomly according to their holding size. The chhitta always provided an adequate number of farmers to fill the lower groups, but the 21-30 and 31 bigha farms and above, were often barely represented. If this was the case, and the required number of

DIAGRAMS SHOWING THE DIFFERENCE BETWEEN HOLDING SIZE LISTED IN THE
VILLAGE RECORDS, AND THE ACTUAL HOLDING SIZE.



Sources: Field work for the Wheat Study - March 1972
and the village records for 1972.

Fig. A.1

farmers had not been obtained from the list because of poorly represented large holdings, the number of farmers necessary to bring the sample size up to 45, were drawn from the lower farm size groups instead. In this way, 45 farmers were selected from each of the six villages and the village lekhpal made arrangements to be present in his village on a particular day. A 50 per cent 'safety margin' was necessary in the size of the sample because many farmers might not have come at the appointed time. Another difficulty was that many farmers who did come, soon became bored and left. This was a very real problem which could only be overcome by having an adequate number of farmers in 'reserve'. Another reason for nominating 45 farmers from the chhitta was, so that as large a sample as possible could be obtained during the day.

Despite elaborate plans to stratify the sample according to the variable of farm size, the attempt can only be deemed as a failure. The actual holding size bears little, and frequently no, relationship to the lekhpal's chhitta (Fig.A.1). One reason is that land is often held in several people's names, and so many of the farmers who were randomly selected for enumeration could not be present as they worked and sometimes lived elsewhere. The land was farmed by relatives in their name.

Many of the farmers on the list had died and their names had not been removed from the chhitta. The land had been divided among their relatives and was now being farmed by several different people. Hence the actual farm size rarely agreed with the lekhpal's records. With such problems as these, it is evident

that a 'safety margin' of at least 50 per cent was necessary, as so many farmers ,even if they were present, did not fulfil the main requirement of the questionnaire; that is, that they should both own and cultivate at least a proportion of their land. The net result was that the sample of farmers enumerated in each village was almost random. As there had been some selection of individuals in the first instance, it meant that the sample could not be truly random, but because the stratification by farm size in the chhitta bore no relationship to field conditions, the final result was a sample that must have compared closely with one which was truly random. Fig.A.1 compares the frequency of the actual farm sizes with the farm size frequency diagram constructed from the chhitta. Although not strictly comparable, as the number of cases on which they are based differs, they do summarize the reason for the failure of this sampling technique.

2. Sampling procedure in the field.

Data were collected in the field from three main sources:

1. Questionnaire survey.
2. Soil sampling.
3. Wheat crop cutting samples.

2.1. Questionnaire survey.

A pre-coded questionnaire was compiled on certain aspects of wheat farming, and 196 farmers in the six villages were enumerated (pp.435-444). Owing to language problems five enumerators, most of whom were students from the Agricultural College at Lakhaoti in Bulandshahr district (Fig.1.4.), were employed for the questionnaire survey. Their knowledge of farming was valuable in ensuring that the farmers understood the questions, and that their answers were consistent with their thorough knowledge of farming practices in the district.

The major part of the field work for the Wheat Study took place between 5th March 1972 and 12th March 1972, after the field work for the District Study. Five of the enumerators from the main study were involved in the Wheat Study, and as the nature of the questionnaire was similar to that of the major District Study, problems in understanding both the method of enumeration and the questions themselves, were far fewer than they might have been. The enumerators had been trained for the District Study, and as a result, the Wheat Study derived great benefit from this previous experience. The questionnaire was tested in one village and modified before use in the field.

Only one village was enumerated each day as the enumerators had to cycle to each village and then back to Bulandshahr in the evenings. The farmers who arrived in the morning were checked with the list of names from the chhitta. If they fulfilled the requirements of the questionnaire, they were enumerated.

Each enumerator questioned no more than four farmers at a time, and by enumerating three to four farmers twice a day, 30 to 40 farmers were questioned in each village. The questionnaire took about two hours to complete. Although there were some clear disadvantages in asking questions of more than one farmer at a time, in practice the procedure proved helpful in providing a situation in which the answers of individual farmers could be checked. Also the field documentation lent itself to this method of enumeration. Care was taken to ensure the group being questioned were compatible individuals, particularly with respect to caste.

A second short questionnaire relating to wheat yields of 1972 rabi was carried out in July, well after the end of the wheat season, when all calculations of yields and costs had been completed (pp. 445-446). The same farmers were called to the villages once more through the village lekhpals and the enumeration process followed the pattern of the first questionnaire survey as closely as possible.

WHEAT STUDY QUESTIONNAIRE.BULANDSHAHR - 1972.Section 1.

- 1.1.¹ In which year did you begin to grow new varieties of wheat. (1965-71).
- 1.2. Which was your main new variety of wheat in rabi 1965-66.
- 1.3. Which was your main new variety of wheat in rabi 1966-67.
- 1.4. Which was your main new variety of wheat in rabi 1967-68.
- 1.5. Which was your main new variety of wheat in rabi 1968-69.
- 1.6. Which was your main new variety of wheat in rabi 1969-70.
- 1.7. Which was your main new variety of wheat in rabi 1970-71.
- 1.8. Which was your main new variety of wheat in rabi 1971-72.
- 1.9. Which was your second variety of wheat in rabi 1971-72.
- 1.10. Which was your third variety of wheat in rabi 1971-72.
- 1.11. Which was your fourth variety of wheat in rabi 1971-72.
- 1.12. Which was your fifth variety of wheat in rabi 1971-72.
- 1.13. Which was your sixth variety of wheat in rabi 1971-72.
- 1.14. How many bighas of new varieties of wheat (total) did you grow in 1965-66.
- 1.15. How many bighas of new varieties of wheat (total) did you grow in 1966-67.
- 1.16. How many bighas of new varieties of wheat (total) did you grow in 1967-68.
- 1.17. How many bighas of new varieties of wheat (total) did you grow in 1968-69.
- 1.18. How many bighas of new varieties of wheat (total) did you grow in 1969-70.
- 1.19. How many bighas of new varieties of wheat (total) did you grow in rabi 1971-72.
- 1.20. How many bighas of new varieties of wheat (total) did you grow in 1971-72.

- 1.21. How many bighas of your main new variety did you grow in rabi 1971-72.
- 1.22. How many bighas of your second new variety did you grow in rabi 1971-72.
- 1.23. How many bighas of your third new variety did you grow in rabi 1971-72.
- 1.24. How many bighas of your fourth new variety did you grow in rabi 1971-72.
- 1.25. How many bighas of your fifth new variety did you grow in rabi 1971-72.
- 1.26. How many bighas of your sixth new variety did you grow in rabi 1971-72.
- 1.27. How many bighas of deshi wheat did you grow in rabi 1969-70
- 1.28. How many bighas of deshi wheat did you grow in rabi 1970-71.
- 1.29. How many bighas of deshi wheat did you grow in rabi 1971-72.
- 1.30. Which variety do you think, would provide the best results on your land.
- 1.31. Which variety do you think, would provide second best results on your land.
- 1.32. Which variety do you think, would provide third best results on your land.

How many years ago did you obtain (buy or were given)
seed for :-

- 1.33. Your main variety of wheat grown this season - rabi 1971-72.
- 1.34. Your second variety of wheat grown this season- rabi 1971-72.
- 1.35. Your third variety of wheat grown this season - rabi 1971-72.
- 1.36. Your fourth variety of wheat grown this season - rabi 1971-72.
- 1.37. Your fifth variety of wheat grown this season - rabi 1971-72.
- 1.38. Your sixth variety of wheat grown this season - rabi 1971-72.
- 1.39. Your deshi variety of wheat grown this season - rabi 1971-72.

- 1.40. Have you had any source of instruction on methods of wheat growing.
- 1.41. What was your main source of instruction .
- 1.42. What was your second source of instruction.
- 1.43. In which year did you receive your main source of instruction.
- 1.44. What was your main source of new varieties of wheat seed - rabi 1969-70.
- 1.45. What was your main source of new varieties of wheat seed - rabi 1970-71.
- 1.46. What was your main source of new varieties of wheat seed - rabi 1971-72.
- 1.47. What was your main source of deshi wheat seed - rabi 1969-70.
- 1.48. What was your main source of deshi wheat seed - rabi 1970-71.
- 1.49. What was your main source of deshi wheat seed - rabi 1971-72.
- 1.50. Has your yield from new varieties of wheat fallen since you started using them.
- 1.51. What yield, on average, have you obtained from new varieties of wheat, rabi before last - rabi 1969-70.
- 1.52. What yield, on average, have you obtained from new varieties of wheat last rabi - 1970-71.
- 1.53. What yield, on average, have you obtained from new varieties of wheat this rabi - 1971-72.

2. Land preparation.

- 2.1. What is the main implement you used for ploughing
- 2.2. What is the second implement you use for ploughing.

When did you purchase one of the following:-
(if more than one, then the first two purchased).

- 2.3. Tractor.

- 2.4. Harrow. (mechanical).
- 2.5. Cultivator (mechanical)
- 2.6. Vah-vah plough.
- 2.7. Victory plough.
- 2.8. Seed drill.
- 2.9. Thresher (electric)
- 2.10. Insecticide spray.
- 2.11. Electric pump.
- 2.12. Diesel pump.
- 2.13. Cane crusher.
- 2.14. Chaff cutter.
- 2.15. Maize cutter.
- 2.16. Bogie.
- 2.17. For how many hours did you hire a tractor for ploughing this season.
- 2.18. What was the cost of the hire.
- 2.19. From whom did you hire it.
- 2.20. Total number of times land is ploughed before new early varieties of wheat are sown.
- 2.21. Total number of times land is ploughed before new late varieties of wheat are sown.
- 2.22. Total number of times land is ploughed before deshi wheat is sown.
- 2.23. How deep do you plough fields for new varieties of wheat.
- 2.24. How deep do you plough fields for deshi wheat.
- 2.25. What is the soil type under your main variety of new wheat-
rabi 1971-72.
- 2.26. What is the soil type under your second variety of new wheat -
rabi 1971-72.
- 2.27. What is the soil type under your third variety of new wheat-
rabi 1971-72.

- 2.28. What is the soil type under your fourth variety of new wheat - rabi 1971-72.
- 2.29. What is the main soil type under your deshi wheat - rabi 1971-72.
- 2.30. What is the main class of land under your new varieties of wheat - rabi 1971-72.
- 2.31. What is the main class of land under your deshi wheat - rabi 1971-72.
- 2.32. Does any part of your wheat growing area adjoin usar land.
- 2.33. Which varieties of wheat adjoin usar land.
3. Sowing of wheat.
- 3.1. Which is the main method you use for sowing wheat.
- 3.2. Which do you think is the most satisfactory method of sowing wheat.
- 3.3. What is the main quantity of new varieties of early wheat seed sown this rabi - 1971-72.
- 3.4. What is the second quantity of new varieties of early wheat seed sown this rabi - 1971-72.
- 3.5. What is the main quantity of new varieties of late wheat seed sown this rabi - 1971-72.
- 3.6. What is the second quantity of new varieties of late wheat seed sown this rabi - 1971-72.
- 3.7. What is the main quantity of deshi wheat seed sown this rabi - 1971-72.
- 3.8. What is the second quantity of deshi wheat seed sown this rabi - 1971-72.
- 3.9. In which weeks of the year did you plant most of your new varieties of early wheat seed - rabi 1971-72.
- 3.10. In which weeks of the year did you plant the remainder of your early wheat seed. - 1971-72.
- 3.11. In which weeks of the year did you plant most of your varieties of new varieties of late wheat seed - rabi 1971-72.

- 3.12. In which weeks of the year did you plant the remainder of your late wheat seed, 1971-72.
- 3.13. In which week of the year did you plant most of your deshi seed.
- 3.14. In which week of the year did you plant the remainder of your deshi wheat seed.

4. Insecticides and pesticides.

- 4.1. What is the main variety of insecticide and/or pesticide that you use for seed protection.
- 4.2. What quantity of insecticide and/or pesticide do you use for removing soil weevils, before sowing wheat.
- 4.3. What quantity of insecticide and/or pesticide do you mix with fertilizer for seed protection.
- 4.4. What is the main variety of insecticide and/or pesticide that you use on plants of the new varieties of wheat.
- 4.5. Which is the main method you use for applying insecticide and/or pesticide to wheat.
- 4.6. How many times do you apply insecticides and/or pesticides to new varieties of early wheat.
- 4.7. How many times do you apply insecticides and/or pesticides to new varieties of late wheat.
- 4.8. How many times do you apply insecticides and/or pesticides to deshi wheat.
- 4.9. How many days after sowing do you treat the crops with insecticide and/or pesticide for the first time.
- 4.10. How many days after sowing do you treat the crops with insecticide and/or pesticide for the second time.
- 4.11. Have you used a crop sprayer this rabi.
- 4.12. Cost of hire.
- 4.13. From whom did you hire it.

5. Weeding of wheat.

- 5.1. How many times do you weed your new varieties of early wheat.
- 5.2. How many times do you weed your new varieties of late wheat.
- 5.3. How many times do you weed your deshi wheat.
- 5.4. What is the main implement you use for weeding.

6. Irrigation of wheat.

6.1. In rabi 1971-72, how many bighas of wheat did you irrigate from:-

6.2. In rabi 1970-71, how many bighas of wheat did you irrigate from:-

6.3. In rabi 1969-70, how many bighas of wheat did you irrigate from:-

1. Open well.
2. Government tube well.
3. Own tube well.
4. Neighbour's tube well.
5. Own pumping set.
6. Neighbour's pumping set.
7. Canal.
8. Pond.

6.4. Sources of irrigation used in rabi 1971-72.
(Reference code above)

6.5. Sources of irrigation used in rabi 1970-71.
(Reference code above)

6.6. Sources of irrigation used in rabi 1969-70
(Reference code above)

6.7. What is the total cost of irrigation water for wheat this rabi - 1971-72.

6.8. What is the total cost of irrigation water this rabi - 1971-72.

6.9. Have you been short of irrigation water this rabi - 1971-72.

6.10. Were you short of irrigation water last rabi - 1970-71.

6.11. Were you short of irrigation water rabi before last - 1969-70.

6.12. What was the main reason for shortage of water in rabi 1971-72.

6.13. What was the main reason for shortage of water in rabi 1970-71.

6.14. What was the main reason for shortage of water in rabi 1969-70.

6.15. Total number of times you have watered your new varieties of early wheat.

6.16. Total number of times you have watered your new varieties of late wheat.

6.17. Total number of times you have watered your deshi wheat.

7. Use of fertilizers.

7.1. What is your main source of fertilizer.

7.2. What is your second source of fertilizer.

7.3. What is your third source of fertilizer.

Quantity of fertilizer you have used in rabi 1971-72.

7.4. Nitrogen.

7.5. Phosphate - super phosphate.

7.6. Potash.

7.7. N.P.K.

7.8. C.A.N.

7.9. D.A.P.

7.10. Urea.

7.11. Sulphate of ammonia or ammonium sulphate.

7.12. Other chemicals.

7.13. Compost.

7.14. Total quantity of fertilizer used in rabi 1970-71.

7.15. Total quantity of fertilizer used in rabi 1969-70.

7.16. How many times did you apply fertilizer to the wheat -
rabi 1971-72.

7.17. Do you think the quantities of fertilizer that you have
used are adequate.

7.18. How much fertilizer have you applied to the new varieties
of wheat this rabi - 1971-72.

7.19. How much fertilizer have you applied to the deshi wheat
this rabi - 1971-72.

8. Harvesting of wheat.

- 8.1. How many sacks/maunds in your total wheat harvest this rabi - 1971-72.
- 8.2. How many sacks/maunds in your total wheat harvest rabi 1970-71.
- 8.3. How many sacks/maunds of wheat harvested from new varieties in rabi 1971-72.
- 8.4. How many sacks/maunds of wheat harvested from new varieties in rabi 1970-71.
- 8.5. How many sacks/maunds did you use as seed for yourself-1971-72.
- 8.6. How many sacks/maunds did you use as seed for yourself-1970-71.
- 8.7. How many sacks/maunds did you sell for food etc. NOT for seed 1971-72.
- 8.8. How many sacks/maunds did you sell for food etc. NOT for seed 1970-71.
- 8.9. How many sacks/maunds of your wheat harvest did you sell to an Agricultural Organisation; 1971-72.
- 8.10. How many sacks/maunds of your wheat harvest did you sell to an Agricultural Organisation, 1970-71.
- 8.11. How many sacks/maunds of your wheat harvest did you sell to an Agricultural Organisation, 1969-70.
- 8.12. In which year did you start growing wheat to sell as seed (new varieties only).
- 8.13. How much wheat for seed did you sell last rabi - 1970-71.
- 8.14. How much wheat for seed did you sell in rabi 1969-70.

9. Information of farm and farmer.

- 9.1. How many years have you been running a farm.
- 9.2. How old are you.
- 9.3. Number of men over 12 years in your family resident with the household.
- 9.4. Number of women over 12 years in your family resident with the household.

- 9.5. Number of boys under 12 years in your family resident with the household.
- 9.6. Number of girls under 12 years in your family resident with the household.
- 9.7. Total number of additional men, women and children supported by the farm.
- 9.8. What is the caste of the family.
- 9.9. Were you a zamindar or the son, or grandson of a zamindar.
- 9.10. What was your tenurial status before 1950.
- 9.11. How much land do you own as a Sirdar.
- 9.12. When did you first obtain Sirdari rights.
- 9.13. How much land do you hold as a Bhumidar.
- 9.14. When did you first acquire Bhumidari rights.
- 9.15. At what age did the person who runs the farm end his education.
- 9.16. Off farm employment of the person running the farm.
- 9.17. How many agricultural labourers or servants are employed permanently on the farm.
- 9.18. Maximum number of temporary workers employed in rabi 1971-72.
- 9.19. Maximum number of temporary workers employed in rabi 1970-71.
- 9.20. How many bundles of wheat in every 100 did you give as wages in rabi 1972.
- 9.21. How many bundles of wheat in every 100 did you give as wages in rabi 1971.
- 9.22. How many bighas do you own.
- 9.23. How many bighas do you farm.
- 9.24. How many chaks do you own.
- 9.25. How many bighas did you own before consolidation.
- 9.26. How many bighas did you own after consolidation.
- 9.27. How many bighas are others farming on a share-crop basis on your land.

- 9.28. How many bighas are you farming on a share-crop basis on others land.
- 9.29. How many bighas of wheat are others farming on a share-crop basis on your land.
- 9.30. How many bighas of wheat are you farming on a share-crop on others land.
- 9.31. How many bighas of wheat do you grow on land that you own (unshare-cropped).

10. Yield of wheat.

- 10.1. Total yield of early wheat.
- 10.2. Total yield of late wheat,
- 10.3. Do you think your yield in 1972 has been higher, lower, same as in 1971.
(higher - 3, same - 2, lower - 1).

What proportion of your wheat crop have you retained for:-

- 10.4. For seed.
- 10.5. For consumption, (including family, friends and relatives).

What proportion have you sold:-

- 10.6. To government agency.
- 10.7. To merchant.
- 10.8. To N.S.C.
- 10.9. To other farmers for seed.
- 10.10. To other agency.

What proportion did you dispose of:-

- 10.11. At the field.
- 10.12. At Bulandshahr.
- 10.13. How far away did you market the main part of your wheat crop.

- 11.1. What was the average price per quintal you obtained.
- 11.2. What was the highest price per quintal you obtained.
- 11.3. What was the lowest price per quintal you obtained.

- 11.4. Proportion of crop threshed by own mechanical thresher.
 - 11.5. Proportion of crop threshed by hired mechanical thresher.
 - 11.6. Cost of hiring mechanical thresher.
 - 11.7. How many days before harvesting did you water your wheat crop.
-
- 12.1. Total sum outstanding on loans.
 - 12.2. Major source of loan.
 - 12.3. Repayment period of your major loan.
 - 12.4. Method of debt repayment:-
 1. cash
 2. crops.
 3. services.

LIST OF CODES

Sections in
Questionnaire. (Numbers in brackets refer to Questionnaire).

1. Varieties. (1.2 - 1.13, 1.30 - 1.32, 2.33).

Codes. 1. RR21.
2. 301.
3. 308.
4. Sharbati Sonora.
5. 1553.
6. 1559.
7. HD 1941 Hira.
8. HD 1944
9. HD 1949 Moti.
10. 1977
11. Sonalika.
12. Other.
13. Deshi.
14. 1593.
15. Lerma Rojo.
16. S64.
17. Kalyan 227.
19. S227.
20. Safed Lerma.
21. PV 18.
22. Kalyansona.

1. Instruction on wheat growing. (1.40 - 1.42).

0. None.
1. Neighbouring farmer.
2. Village level worker.
3. Agricultural college of Block or district.
4. National Seed Corporation.
5. Direct from IARI, Pusa.
6. Direct from Pantnagar University.

1. Source of Seed. (1.44 - 1.49).

1. Agricultural Department.
2. Agricultural College of Block or district.
3. Co-operative Society.
4. National Seeds Corporation.
5. Private Merchant.
6. Neighbouring farmers.
7. Tonnage club.
8. Pantnagar University agent.
9. Self.
10. Other.
11. Direct from IARI, Pusa.
12. Direct from Pantnagar University.

Sections in
Questionnaire. (Numbers in brackets refer to Questionnaire).

2. Ploughing implements. (2.1 - 2.2).

- Codes.
1. Wooden plough.
 2. Vah-vah plough.
 3. Cultivator.
 4. Tractor.
 5. Tiller.
 6. Harrow.

2. Sources of hired goods. (2.19).

1. Neighbour.
2. Agro-Industries.
3. Relative.
4. Other.

2. Soil Texture. (2.25 - 2.29).

1. Sandy: particles separate, will not stick together.
2. Sandy-loam: very slight tendency to stick together, particles separate readily.
3. Loam: friable, particles stick together, good crumb structure.
4. Clay-loam: particles stick together readily when pressed; separate with difficulty.
5. Clay: particles will not separate; not possible to feel individual particles.

2. Land Class. (2.30 - 2.31).

1. A.
2. B.
3. C.
4. A/B.
5. B/C.

3. Sowing implements. (3.1 - 3.2).

1. Scatter by hand behind plough.
2. Hand operated seed drill, bullock drawn.
3. Bamboo funnel.
4. Mechanical seed drill.
5. Broadcasting by hand.
6. Dibbler.

Sections in
Questionnaire. (Numbers in brackets refer to Questionnaire).

4. Insecticides and Pesticides. (4.1, 4.4)

- Codes.
- 0. None.
 - 1. Gammexane.
 - 2. Aldrin.
 - 3. Dieldrin.
 - 4. Agrosan GN.
 - 5. Zinc Sulphate.

4. Crop Sprayers. (4.13).

- 1. Neighbour.
- 2. Block.

4. Insecticide and Pesticide application. (4.5).

- 1. Spray.
- 2. Broadcasting.
- 3. Other.

5. Methods of weeding. (5.4).

- 0. None.
- 1. Kurpa or hand hoe.
- 2. Spiked toothed harrow.
- 3. Sprayer.

6. Water shortage reasons. (6.11 - 6.13).

- 0. No shortage.
- 1. Canal water insufficient.
- 2. Government tube well water insufficient.
- 3. Power shortage of own tube well.
- 4. Power shortage of neighbour's tube well.
- 5. Diesel breakdown.
- 6. Neighbour's diesel breakdown.
- 7. No source of irrigation.
- 8. Open well water insufficient.

7. Source of fertilizer. (7.1 - 7.3).

- 0. None.
- 1. Block.
- 2. Private merchant.
- 3. Cane Society.
- 4. Other.

Sections in
Questionnaire. (Numbers in brackets refer to Questionnaire).

9. Caste. (9.8)

- Codes.
1. Jat.
 2. Brahmin.
 3. Tyagi.
 4. Rajput.
 5. Saini.
 6. Bania.
 7. Khetri.
 8. Lodha.
 9. Chamar.
 10. Gujar.
 11. Ahir.
 12. Other Hindu.
 13. Sheiks.
 14. Pathan.
 15. Saiyad.
 16. Other Muslim.
 17. Sikh.
 18. Christian.
 19. Mohammedan Rajput.
 20. Other.
 21. Goswami.
 22. Shepherd.

9. Tenurial Status. (9.10).

1. Z amindar.
2. Tenant.
3. Owner.
4. Other.

9. Education. (9.15).

0. None.
1. Primary school.
2. High school
3. Secondary school
4. Technical college.
5. Other adult education.
6. University.

9. Off farm employment. (9.16).

0. None.
1. Profession e.g. medicine or law.
2. Wholesale trade.
3. Teacher / Lecturer.
4. Government.
5. Police / Army.
6. Retail trade.

Sections in
Questionnaire. (Numbers in brackets refer to Questionnaire).

9. Off farm employment - Continued.

Codes. 7. Skilled trade.
8. Agricultural labouring.
9. Other labouring.
10. Other.

Answers requiring either yes or no. (1.50, 2.32, 4.11,
6.8 - 6.10, 7.17,
9.9)

0. No.
1. Yes.

-.001 Not applicable.
-.005 No answer.

2.2. Soil sampling.

The samples of soil were all collected on the same day as the enumeration. Again, no more than one day was spent on this, except in the case of the village of Chirchita, where the soil samples were collected on three consecutive days.

1. Selection of soil sample sites.

Soil samples were collected in order to obtain an indication of the nature of the soil present in each village. Post consolidation field boundaries had been mapped at a scale of 16 inches to one mile, and so, when the farmers who were to be enumerated had assembled, their chaks¹ were identified and marked on the map. 12 chaks were sampled from each village. These sites were purposively selected so that there were no large parts of the village which were left unsampled. Had random tables been used to locate 12 sample sites, the inadequate sample size might well have resulted in clustering. It was felt that the more subjective method was preferable in this case.

2. Collection of soil samples in the field.

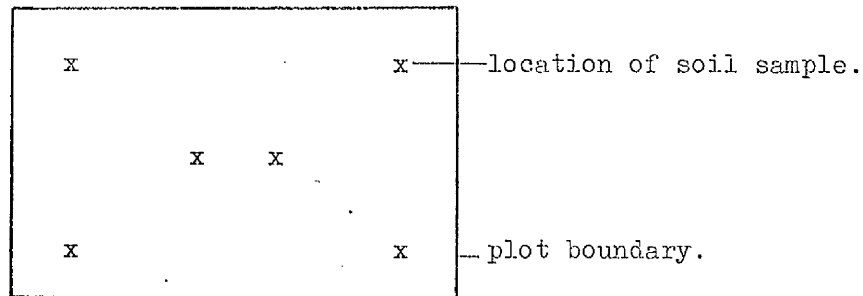
Once the sample chaks had been located in the field, the position of the area to be sampled was determined. The samples were always taken under wheat and not from under any other crop. If there was more than one plot of wheat on each chak, the largest plot was sampled.

The method suggested by the Indian Agricultural Research

1. chaks - post consolidation plots of land.

Institute Soil Department was used when soil was being collected from each plot. Average conditions for the plot were obtained by taking samples to a depth of 30 cm. (12 inches) from different parts of the plot, and mixing them. Six samples were taken from each plot, and their positions were standardized. (Fig.A.2).

Diagram to show approximate position of soil sample sites in each plot.



Source: Field work for the Wheat Study - March 1972.

Fig.A.2.

This, it was felt would give an indication of the type of soil in the plot. The method used here followed very closely the methods used for soil sampling in the District Study 1972.

The samples were only taken to a depth of 30 cm. Although it is known that wheat yields are influenced by conditions at one metre below the surface¹, the shallow samples were thought to be adequate for the following reasons:

1. Hand augers were used and the physical effort of obtaining soil deeper than 30 cm. was often so great that the stipulated number of samples would never have been collected.
2. A soil study was not the main aim of the project, and as other soil data of conditions at greater depth were available from the

1. Landbon Whogeschol Afd. Cultuurtechniek, 1964, 'Crop yields in relation to depth of ground water table'. College Aarntekeningen, drainage. p.8.

U.P. Soil Survey Department, they were thought to be adequate. The methods being used in the field were not sufficiently accurate to obtain a soil profile of good descriptive quality, and this would have been necessary in order to isolate samples from different depths in the horizon. The moisture content of the soil was frequently low, and the sandy and silty textures caused the soil loosened by the augers, to mix. So it was felt that with the time and equipment available, no better data than that of the U.P. Soil Department, on soil conditions at greater depths, could be produced.

3. The methods employed were those recommended by the Indian Agricultural Research Institute at Pusa, New Delhi. According to them, the requirements of wheat, in terms of fertilizer, could be assessed from such soil samples, and also there would be some indication in the surface layers of whether or not the farmer had been applying adequate fertilizer. The collection of the soil within the space of 10 days permitted comparisons with regard to the soluble salt content of the soil. This could not be done if the samples were collected throughout the year.

The samples of soil from each plot were placed in polythene bags and sun dried before being taken to the Indian Agricultural Research Institute Soil Department where they were analysed for both selected physical and chemical characteristics.

2.3. Wheat sampling.

Samples of the wheat crop were taken from one village only - Chirchita. It would have been preferable to collect samples of wheat from each of the six villages, but as samples had to be

cut on the day of harvest of the field, it was impossible to cover all the villages when the wheat crop is all being harvested simultaneously.

1. Selection of the plots from which samples were cut.

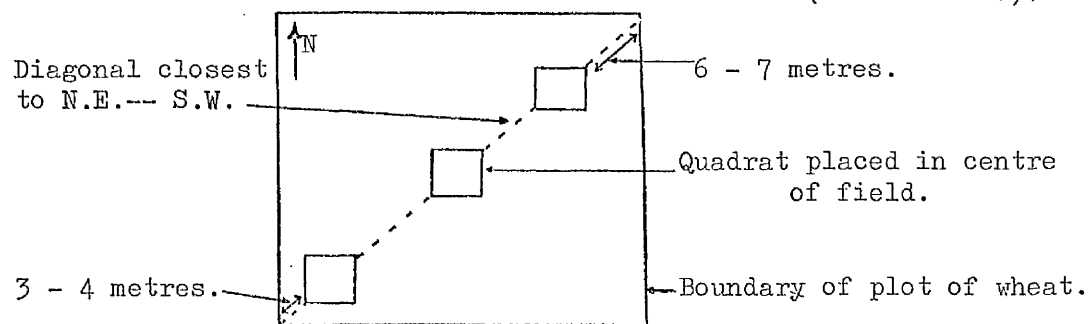
Cutting samples were taken from one plot of each of the farmers, randomly selected for the questionnaire survey. Soil samples too were taken from these same plots on which wheat was grown.

2. Size of the cutting samples.

Three quadrats each one metre square were placed along the diagonal of the plot which approximated most closely to north-east to south-west. This was to systematize the cutting procedure. One metre quadrat was placed in the centre of the field, a second three to four metres from one corner, and a third six to seven metres from the other corner (Fig.A.3). This represented conditions at the edge and nearer the centre of the field.

Diagram to show the location of the quadrats in each wheat field.

(not to scale).



Source: Field work for the Wheat Study - March 1972.

Fig.A.3.

All plants, both the wheat and the weeds, in each quadrat were pulled from the ground, together with those plants on the periphery where more than half their basal area was in the square. As much of the root matter as possible was obtained with the wheat, so that the number of plants per square, and the number of tillers per plant could be determined. The three samples were collected and stored separately so that comparisons could be made between conditions in different parts of the field.

One of the major problems associated with the wheat sampling was storing the cut samples. Despite the apparent dryness of the crop, there was adequate moisture present to permit bacterial action and decomposition of the plants to begin. Threat of damage from insect pests was also a problem. Consequently, the samples had to be dried before they were stored in sacks and transported to the Indian Agricultural Research Institute at Pusa, New Delhi, where they were analysed by the wheat breeding section.

3. Criticism of certain aspects of the sampling procedure and the data collected.

Data from several sources have been used in this project, but they fall into two main groups:

1. Primary material.

Data collected from the questionnaire survey.

Primary material on soil collected in the field.

Primary material on wheat collected in the field.

2. Secondary source material.

3.1. Primary material.

1. Data collected from the questionnaire survey.

1. The questionnaire was pre-coded and the data collected directly on to computer coding forms in numerical terms (Fig.A.4). This was a great asset as it eliminated lengthy post-coding and copying errors. One of the greatest problems of pre-coding a questionnaire, is that the list of options is insufficient. In this case however, with the experience gained from the District Study and with the assistance of its enumerators in testing the Wheat Study questionnaire, the pre-coded options were found to be adequate.

2. Studies based on questionnaire work are often viewed with suspicion, as the accuracy of the data is always in doubt. Such a criticism can never be disputed and must always be a limitation of this type of study. It must be said that there was no reason to suspect that the answers to the questions were far from the truth, as the farmers were always co-operative and willing to talk. Group interviews were one way in which gross

exaggerations were recognised. However, it must be emphasised that the interest and willingness of the farmers to answer the questions was reason enough to have confidence in the data which was collected.

3. The technique of group enumeration was adopted, and although the results of this are not as valuable as the one farmer/one enumerator approach, when time and money are in short supply, it has numerous advantages. It is a rapid method of collecting data. In one day the farmers had little time to consider the questions at length, and the possible answers they could give. Often the spontaneous answer is the right one, but deviations from the truth can occur if enumeration takes place over several days and answers are no longer spontaneous. On the other hand it could be argued that spontaneous answers contain a high proportion of mistakes. It was decided to collect data rapidly and accept the limitations of the material. One problem of the approach was that a farmer could repeat the answer of his neighbour if he did not know what to say himself. If the answer was quite untrue, it was frequently and readily contradicted by the other members of the group.

Despite all these limitations, it was felt that the questionnaire survey could provide results which would be of value to the study.

4. The detailed nature of the questionnaire gave cause for slight concern, but once the enumerators had grasped the aims of the questionnaire, the farmers had no difficulty in

answering the questions. It was originally thought that remembering as far back as rabi 1969-70, from rabi 1972, might produce gross inaccuracies, but according to the enumerators, and judging from the results, the farmers were able to cope with the questions.

5. One of the major controls over the quality of the data was the ability and enthusiasm of the enumerators. Again, the value of a single enumerator, preferably the research worker, is evident. In such a project as this where rapid data collection is required, a compromise had to be made between speed and accuracy. Again, as with the answers to the questions, the accuracy of the work of an enumerator cannot easily be judged. However, the careful instruction and practice which the enumerators obtained from the District Study give confidence in the quality of the data which has been collected for this Wheat Study. The data collected each day were checked and discussions of doubtful answers took place the following morning.

2. Primary material on soil collected from the field.

1. The soil was sampled to a depth of 30 cm. (12 inches) and so gives no indication of conditions at greater depth. This could be an important omission in the case of the Wheat Study. Reasons for the method adopted were explained in section 2.2. of the Appendix. It is adequate for a general assessment of conditions, but would not suffice for a more detailed project on soil.

2. The soil samples were analysed at the Indian Agricultural Research Institute, Pusa, New Delhi. The methods

used for analysing the soils of local farmers. The depth of the analysis could not be great as the samples had to be analysed by people not concerned with the project. For similar reasons the level of accuracy of the results could also be questioned. With these limitations in mind, the data have been used, to a limited extent, and it is on account of these problems that the variables of soil have not been of very great importance in the analysis.

3. Primary material on wheat collected in the field.

1. No definite conclusions could be reached relating to the yield of the crops in Chirchita village, the approach to the cutting of the samples was systematic and they were extremely small. Nothing could be done about this as the farmers refused to accept money for the crops. It was felt that this was the largest area that could justly be taken from them.

2. Samples of wheat were cut only in Chirchita village as it was essential that as little variation as possible should occur in the methods used for cutting the wheat. I tried either to be present or to cut each wheat sample in Chirchita, in order to minimize the variation in the method. This would not have been possible had samples been collected from every one of the study villages, and as I was anxious to standardize the approach to this aspect of the data collection in particular, the crop cutting samples were limited to one village only.

3. Despite all efforts to reduce the error at the time of cutting, there must have been some loss when the wheat was

being transported from the field to the village, and then again on its journey to the Indian Agricultural Research Institute at Pusa, New Delhi. Some of the samples showed signs of attack by a form of mildew, but the physical characteristics of the wheat were rapidly analysed at Pusa, and so it was felt that the results would be less affected by this problem than by the former one of loss and damage in transit.

Owing to these problems, the results of the crop cutting samples have been treated with reserve. They have been used here, as the methods used and the intensity of the sample compare favourably with the crop cutting samples of the IADP, of the district agricultural department in their estimation of crop yield, and provide the yield estimates of the National Sample Survey. In all these cases the individual crop cutting samples have been much greater in area than those of the Wheat Study, but the intensity of the samples is, in every case, far less. While it is felt that the data are inadequate for providing definite statements about the wheat yields of Chirchita, any conclusions that are drawn are felt to be no less valid than those of the three data collecting organizations cited above.

3.2. Secondary source material

The quality of data depends on the methods of its collection. If these are not of a high standard, the results are likely to be biased. Primary material collected in the field is always preferable to secondary source data, as all the limitations are known in the case of the former, and the quality of the data can be assessed.

Secondary source material presents much difficulty in its interpretation. The limitations of the data resulted from the methods of collection are not readily apparent, and so the data are often deceptive. Owing to the lack of confidence in secondary source material, the major part of this project has been based on the results of new data collected in the field. Even if the quality of the primary data is inferior to the secondary source material available, the raw data are preferable as their limitations are known.

Secondary source material has been of great value in this project as it has provided all the background material for it. Data of two kinds have been used:

1. Qualitative data.
2. Quantitative data.

1. Qualitative material

The major part of the qualitative material on Bulandshahr district has been incorporated in Chapter 3. Areas and events have been vividly described in government reports, memoirs and other publications discussed in Chapter 3, and these have been of interest to the study. Although qualitative material is usually criticized for being imprecise, this did not detract from the value of the material which was highly detailed in its descriptive form. The most useful qualitative material relating to Bulandshahr district extended from the middle of the nineteenth century to the very early part of the twentieth.

The various accounts of the district, all of which have been

H. V. P. Leaflet No.10

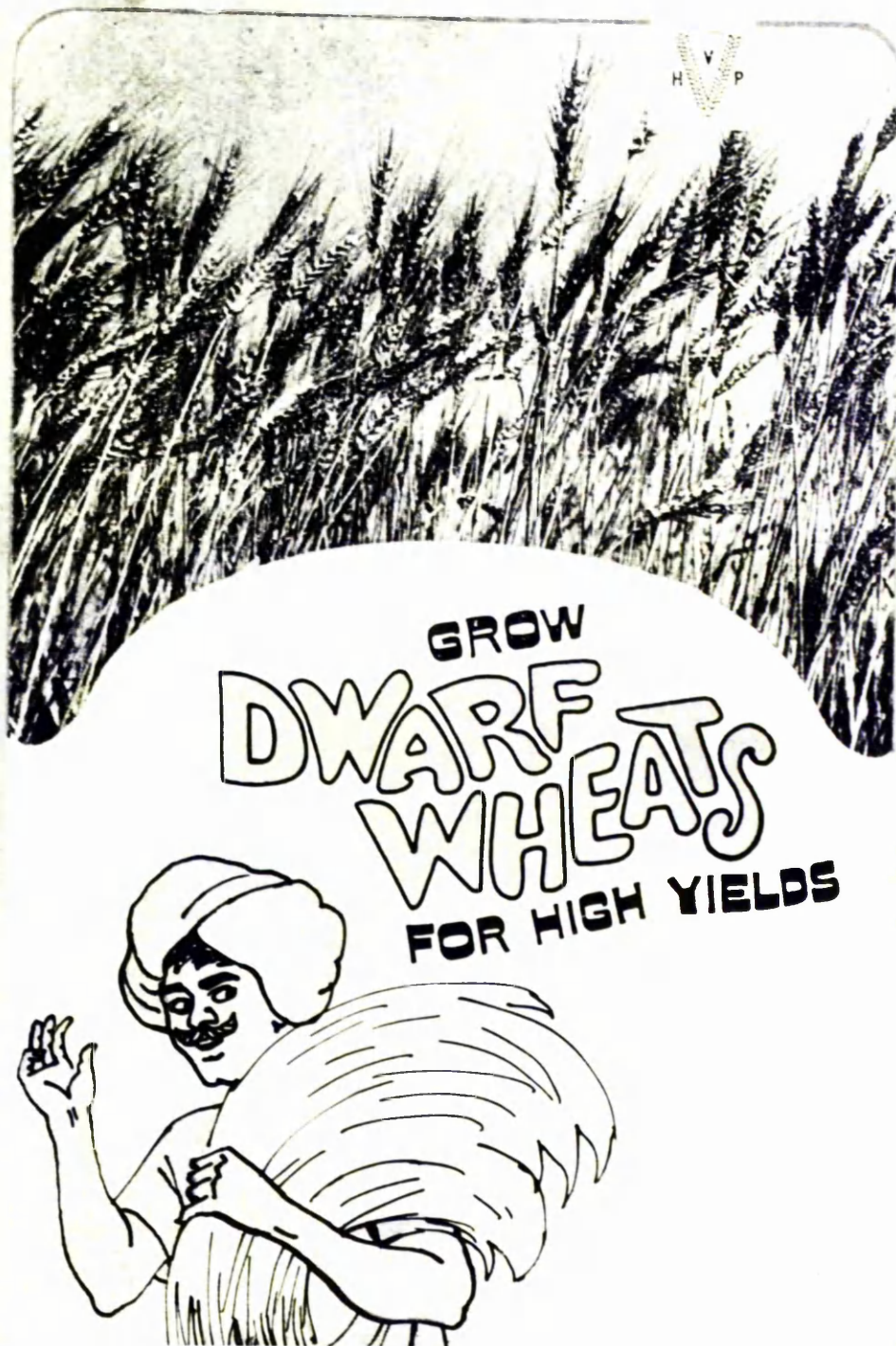


Fig.A.5.

The HYVP Booklet.

FOR
HIGH YIELDS
FROM
DWARF WHEATS
FOLLOW THE
PACKAGE OF IMPROVED PRACTICES



GROW DWARF WHEATS FOR HIGH YIELDS

For extra high yields grow dwarf wheats. You now have a variety of them to choose from :

Kalyan Sona, which has amber grains, matures in 4 to 5 months.

Sonalika, which also produces amber grains comes to maturity in 4 months. *Sharbati Sonora* is another dwarf wheat with similar characteristics. Both the varieties are suitable for late sowings. *Sharbati Sonora*, however, is susceptible to rust. Hence, do not grow it in areas where the rust disease is common.

Safed Lerma and S-331 (or Chhoti Lerma) produce white grains. Both these varieties mature in 4 to 5 months.

Lerma Rojo and PV-18 have light red grains and get ready in 4 to 5 months.

Adopt the following package of practices to get the best yield from any of the dwarf wheats you choose.

Select a land

Select a well-drained land for wheat sowing. See that it is levelled, so that you can irrigate it uniformly.

Apply fertilizers

Dwarf wheats demand heavy fertilization to yield well. Get your soil tested and apply fertilizers according to the recommendations of the soil testing laboratory.

In the absence of a soil test report, you can follow this general recommendation :

If you are growing the dwarf wheat after jowar, maize and bajra, give 100 to 120 kilos of nitrogen per hectare. But, if the land was left fallow in kharif or was sown to a legume, give about 80 kilos of nitrogen per hectare.

Also supply 50 to 60 kilos of phosphoric acid per hectare.

If you are growing the crop on a light soil, you will have to give potassic fertilizers as well. Broadcast 36 kilos of potash (60 kilos of muriate of potash) per hectare.

Apply all the phosphatic and potassic fertilizers and half the quantity of the nitrogenous fertilizer just before sowing. Apply the remaining half of the nitrogenous fertilizer just prior to first irrigation. Band placement of phosphatic fertilizer, however, gives a better result.

Control weeds

Spray sodium salt of 2, 4-D at one kilo per hectare, 4 to 6 weeks after sowing (when the plant has given out 4 to 5 leaves). This will control broad-leaved weeds. It will be harmful if the spraying is done earlier or later than this period.

Prepare the field

Bring the soil to a fine tilth by ploughing deep with a soil-turning plough and following it with harrowing. Give a pre-sowing irrigation. After the land is in condition, give one or two shallow ploughings. Thereafter, run a *sohaga* (levelling plank).

Treat the soil

If the white ant or *ghujia* attack is apprehended, broadcast 25 kilos of 10 per cent BHC or 10 kilos of 5 per cent aldrin per hectare just before the last ploughing. This will prevent white ant and *ghujia* attack.

Treat the seed

If the seed has not already been treated, treat it before sowing with an organo-mercurial compound at one part of the chemical for every 300-400 parts of the seed.

Caution : Do not use the seed treated with an organo-mercurial compound as food or for feeding birds and animals.

Sow with care

Sow the seed shallow to an optimum depth of 4 to 6 cm. and in rows 15 to 22 cm. apart. This will ensure uniform germination.

You will need 100 to 125 kilos of the seed to sow a hectare. If you are growing a bold-grained variety like Sonalika or S.305, use a higher seed-rate.

If possible, use a seed-drill for sowing the seeds.

Irrigate regularly

Irrigate the crop as and when necessary. Give the first irrigation at the 'crown roots initiation' stage (between the third and fourth week of sowing). Irrigations should be given at late tillering, flowering and dough stages to the wheat raised on light or heavy soil. Irrigation at the dough stage should be given on a non-windy day. Two or more extra irrigations may be needed in the case of light soil.

Protect the crop

Excepting for white ants and occasional appearance of some minor pests, a wheat crop normally remains free from insect attack. However, due to the large dose of fertilizers and frequent irrigations that are required to be given to the dwarf wheats, insects like grasshopper, weevil, aphid and armyworm, are likely to appear and cause damage. In addition, diseases like rusts, smut, bunt, earcockle, yellow rot, flag smut and black tip are quite common. Take prompt control measures against insects and diseases, as soon as you notice them. Consult your local Agricultural Extension Officer for control measures to be taken up. You may also refer to the leaflet entitled 'Keeping wheat free of insects and diseases', of the Directorate of Extension.

Kill the rats

Rats cause considerable damage to the wheat crop in the field, especially during the earing stage. Kill rats by poison baiting with zinc phosphide. For this, mix one to two parts by weight of zinc phosphide, two parts of edible oil or three parts of molasses with 10 or 12 parts by weight of a carrier such as wheat

or crushed grain or pulses or bran or flour. Ten kilograms of the bait mixture will be sufficient for 8 hectares. You can control rats by fumigating live burrows with 0.75 gram tablets of aluminium phosphide also. Rats are better controlled when all farmers of an area take up poison baiting jointly.

FOR SPECIFIC RECOMMENDATIONS FOR YOUR AREA, CONSULT YOUR GRAM SEVAK OR AGRICULTURAL EXTENSION OFFICER.

H.V.P. Campaign Leaflet No.10

This replaces all the leaflets previously issued by the Directorate on growing wheat, including the H.V.P. leaflet No.7.

*Ask for other leaflets on
high-yielding varieties*

1. Keep wheat free of insects and diseases
2. Growing the high-yielding I.R. 8 paddy
3. Raise high-yielding maizes
4. High-yields with hybrid bajra
5. Getting high-yields with hybrid jowar
6. Protect Taichung Native-1 and
I.R. 8 paddies from pests and diseases
7. Controlling pests on high-yielding maize
8. Protect your hybrid bajra crop from pests
9. Protect hybrid jowar crop from pests
10. High-yielding wheats make tasty dishes
11. Nice dishes with high-yielding rice
12. Better dishes with hybrid bajra
13. Hybrid jowar recipes you will relish
14. You will like these hybrid maize recipes

cited in Chapter 3, agree on points of detail, but there does seem to be a tendency for the qualitative material to refer heavily to the Report of the Settlement of 1865,¹ and so it could be argued, that their similarity in detail results from the fact that they are all based on this document. However, as the qualitative material has been used together with observation merely to provide a description of terrain, drainage and agriculture in Bulandshahr district, the material is felt to be adequate.

More recent forms of qualitative material have been used throughout the dissertation. Some of the most interesting and informative perhaps, have been found in bulletins published by the Indian Agricultural Research Institute and the Indian Council of Agricultural Research. Much of the published material is aimed at encouraging the spread of the high yielding varieties, and one such propaganda leaflet is included in the text. (HYVP leaflet no.10) (Fig.A.5). The limitations of depending heavily on such forms of data are readily apparent, and it is for this reason that the major part of this dissertation is based on material collected in the field.

2. Quantitative material.

There is a wealth of quantitative material which provides much support for the claims of the qualitative material. The data most used were statistics on certain aspects of agricultural change, the various sources of which have been cited in Chapter 3. The systematic collection of statistical material annually, is remarkably thorough, as is apparent from the fraction of it used in Chapter 3. Despite this apparent thoroughness, the

1. Currie, R. 1865, General Report of the Settlement of the Bulandshahr district. Lucknow.

material has not been subjected to statistical tests. This would have been unjustifiable as the methods used for estimating areal and production statistics are not adequately described in the accompanying texts. This lack of confidence in the statistics has not prevented them from being a great asset to the study. Although inference about relationships between variables cannot be made with certainty, the statistical material does lend a great deal of precise information to the project, which complements the qualitative material with respect to the changes in agriculture which have occurred in Bulandshahr district.

As with the qualitative material, the statistics do show some lack of continuity. The excellent coverage of certain aspects of agriculture as illustrated through the journal 'Indian Agricultural Statistics', exists over a period of approximately half a century, from the 1880s to the 1930s. By the later date Independence movements were gaining momentum, and this together with World War II led to a decline in the quality and the quantity of the records. Many of the data during this period are missing, and comparative material is relatively scarce. After 1950 and the launching of the First Five Year Plan, the Indian Government resumed fairly detailed collection of agricultural statistics. Most of the statistically descriptive material for the past 20 years has been taken from the Annual State Bulletin of Agricultural Statistics.

The categories under which data are recorded are briefly defined in the texts but leave much unsaid. Again, comparisons of material of pre and post British India are difficult to make,

as it is never certain if and how any of the agricultural categories has been re-defined.

One instance where this seemed to have taken place, post 1947, was in the land use category of 'Permanent pasture and other grazing lands'. Until 1965 this category had occupied 0.4 per cent of Bulandshahr district, when permanent pasture suddenly jumped to occupy 4.0 per cent of the district. Although this is a relatively insignificant category, it illustrates a point. There was no indication given in the Bulletin of Agricultural Statistics as to the reason for this sudden increase by a factor of ten. It could have been an error, but the change seems to have been maintained. It could have been the result of new developments in the government policies for dairy farming. It could have been that the Uttar Pradesh Department of Agriculture had re-defined the category. The last possibility certainly seems the most likely, but in any event it illustrates the problems in interpreting such data.

Comparisons of statistical data are often made impossible when the categories under which data are collected are altered. To illustrate this, an example will be cited from a Government of India publication 'Indian Agricultural Statistics' (1883-1947), a journal much referred to in the Wheat Study. In 1883, when data were initially recorded, the main sources of irrigation were canals and wells, as the areas irrigated were from these two sources together with a third source called "other". In 1893, the area irrigated from tanks was suddenly introduced, and it seems likely that this was separated from the category of 'other', as this showed a decline which approximately matched the area

irrigated from tanks. It is not clear whether the entire area irrigated from tanks was previously categorised as 'other' or not, or why the division occurred. In fact the definition of 'other' is unclear and the dividing line between ponds, tanks and wells is blurred.

The areas sown to food crops and non-food crops were recorded from 1883 to 1889. After this date, these statistics ceased to be recorded. It is probable that they could be compiled from a summary of the areas under the individual crops listed. Nowhere is there any indication of whether or not the crop list is exhaustive and so, if this had been assumed, the results would have been questionable.

These data were all plotted on absolute scales as visual aids in the analysis of the data. It could be argued that changes in the patterns of land use, largely concentrated in Chapter 3, would be more meaningful if the data were plotted on a semi-logarithmic scale. This would have the value of showing relative levels of change rather than the absolute changes shown in the diagrams of Chapter 3. Absolute scales were preferred, however, because these enabled a comparison of the production of wheat with the production of barley and gram in any particular season, and it was felt that this was of value in the study.

It is appreciated that relative changes over time are not readily apparent from absolute data and may require a logarithmic scale, but after experimentation with both methods, it was found that the use of a logarithmic scale which has the ability to

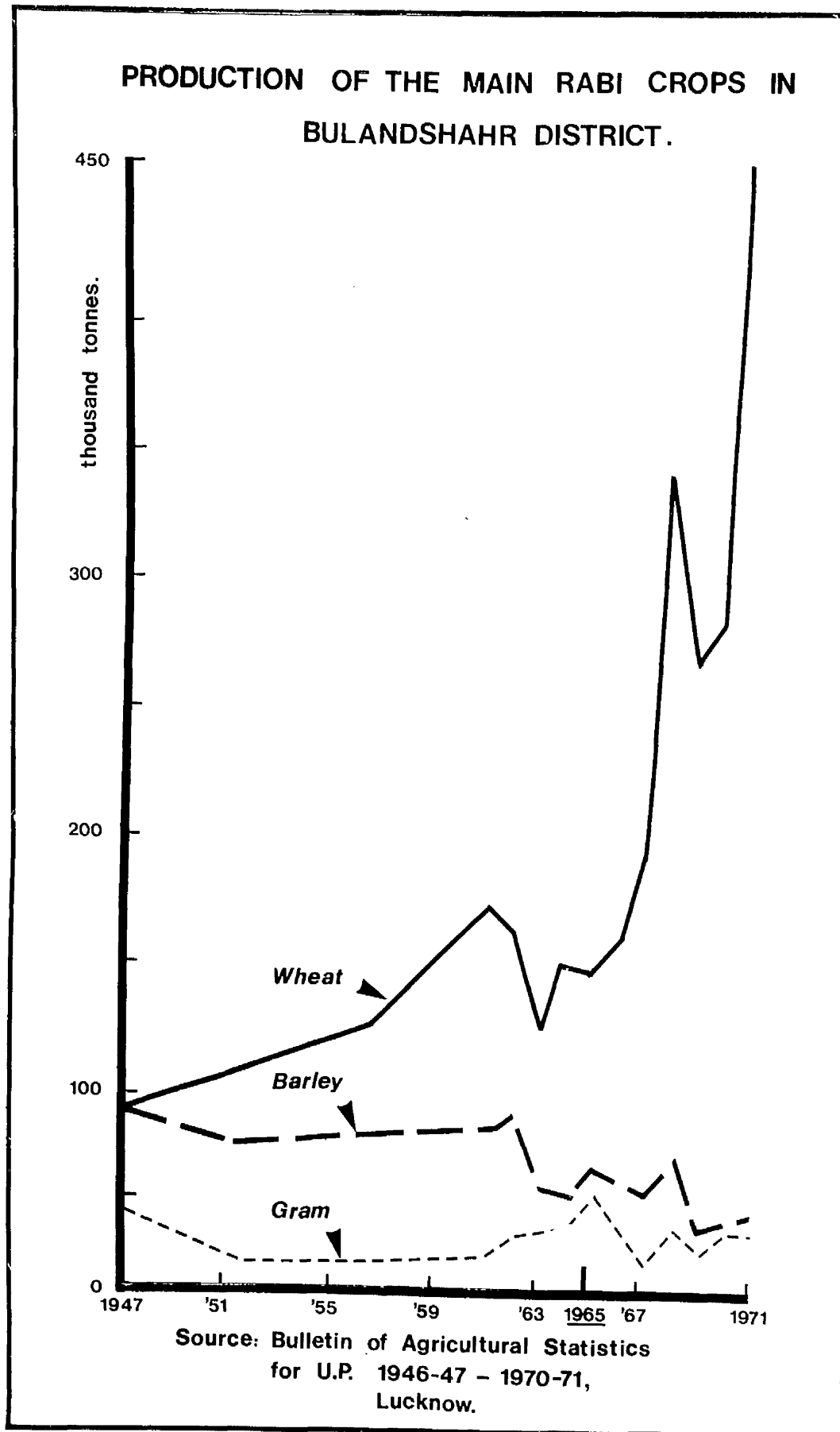


Fig. A.6

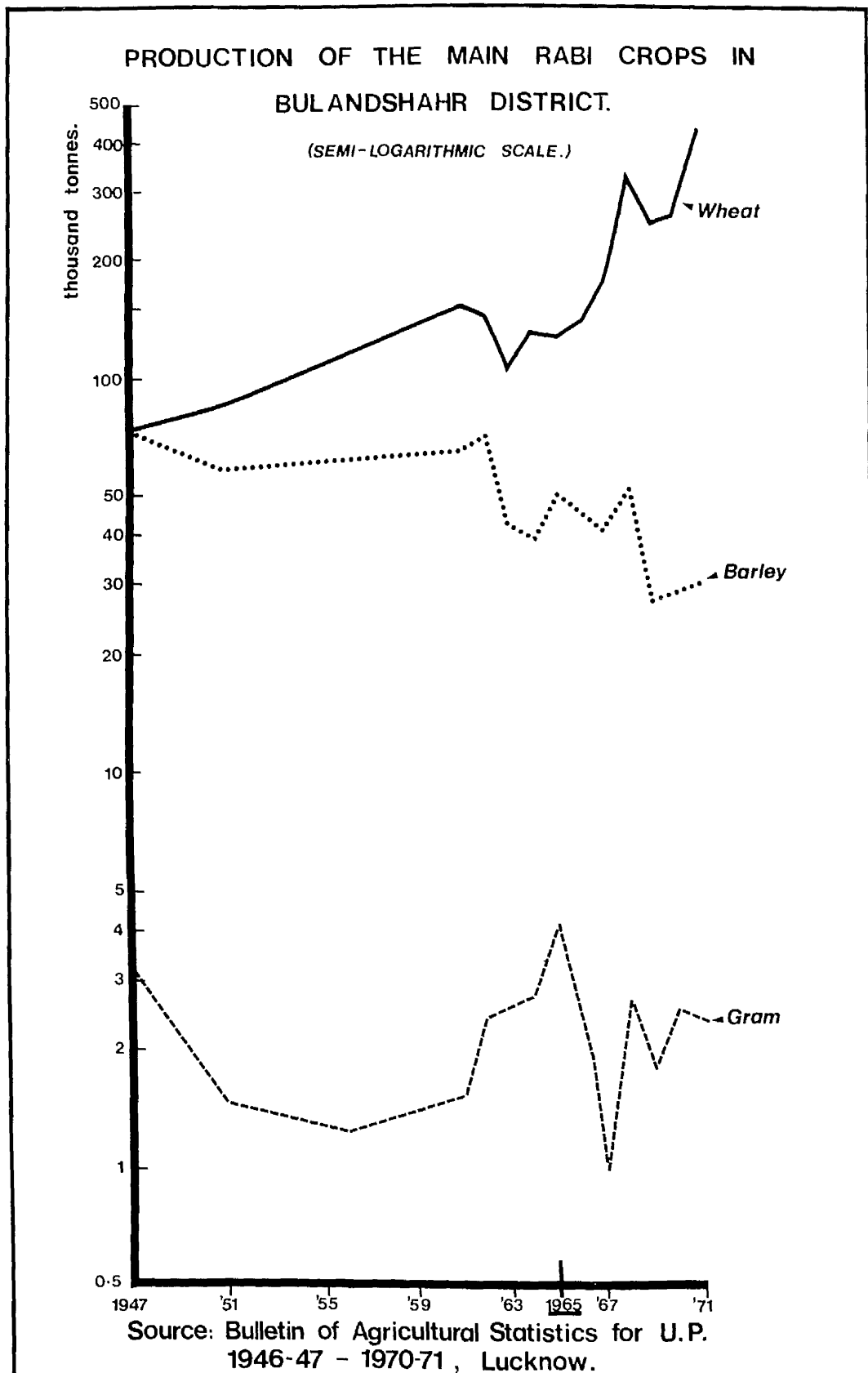


Fig. A.7

'smooth' irregular curves and so clarify trends, is of little benefit if the data do not span a considerable range. If the greatest value to be plotted does not exceed the smallest by at least a multiple of seven, and preferably ten, the shape of the semi-logarithmic graph was found to vary little from the graph showing absolute change over time. Figs.A.6. and A.7. show the same data plotted first on an absolute scale and then on a semi-log. scale.

It can be argued that variations in a curve are maximized if an arithmetic scale is used and so are illusory. The use of a semi-logarithmic scale may help to overcome these illusions. The seemingly enormous rise in wheat production (Fig.A.6) is tempered when plotted on the semi-logarithmic scale (Fig.A.7). If however, the data values are declining, as they are in the case of barley and gram production after 1965-66, (Fig.A.6), the variations in the curve are emphasized if they are plotted on a semi-logarithmic scale (Fig.A.7), and so an arithmetic scale may be preferable if optical illusions are to be kept to a minimum. As the analysis of the statistics was to be continued at no greater depth, it was decided to use arithmetic scales in the majority of cases.

Apart from agricultural data, secondary source material was used to examine certain aspects of population change in Bulandshahr district. The District Census Handbooks are necessary for the detail in this case, but as they were unavailable for censuses prior to 1961, the relevant Uttar Pradesh census volumes were consulted. In these, data are rarely presented in the same

form. This provided problems in compiling material, particularly that which referred to the administrative areas within the district, for instance, tehsils.

In the light of the many changes in operational definition it would be unjustifiable to subject the secondary data to rigorous statistical test and analysis. The secondary sources did, however, provide a background against which to set the detailed field studies.

4. Relationships between the statistically 'independent' variables.

Eight variables which, from observation, seemed likely to affect wheat farming techniques, were selected as statistically 'independent' variables for the Wheat Study. Unfortunately they are far from independent of each other in the conventional sense, and so a detailed analysis of their inter-relationships has been included in this section of the Appendix.

The main 'independent' variables are:-

1. Climate.
2. Soil.
3. Village identity of the farmer.
4. Caste of the farmer.
5. Size of the area farmed.
6. Education level of the farmer.
7. Zamindar or close relative.
8. Year of instruction in new farming techniques.

1. Climate.

The first statistically 'independent' variable is probably little affected by other variables of the Wheat Study as the topography varies so little over the district (Fig.3.3). As the area within which the six villages lie is small, approximately 300 sq. km. (Fig.1.4), there is little purpose in analysing the data with respect to real differences in climatic conditions. For the purpose of this study, climatic effects will be taken as constant over the entire Wheat Study area.

2. Soil.

The soil is influenced by climatic conditions, but again

the constancy of climatic effect over a limited area of relatively unchanging base material cancels out the effect of this relationship (Fig.A.7). Local variation in soil conditions however, may be of importance in influencing decisions taken by farmers; the amount of water and fertilizer required are two variables which would be influenced by soil differences. Soil does not act in isolation as it is influenced by the farming methods used; inputs of water, fertilizer and pesticide for instance, are bound to have some effects on the nature of the soil. The variables 'village identity' and 'caste' could indirectly affect the soil through the decisions taken by the farmers, but the extent of these effects cannot easily be quantified. Soil does not influence the decisions of the farmers without being affected itself, and so its influence on the dependent variables cannot be assessed precisely. It none the less seemed worthy of further investigation in the thesis, particularly in terms of its physical structure which is less easily affected by external variables than is the chemical nature of the soil.

3. Village Identity of the farmer.

Each village seemed to possess a character of its own and it was felt that this might be reflected in the individual cultivator's approach to wheat farming, even though it was not known whether the patterns of decisions varied from village to village. When asked, the farmers could provide little information about the influence of the village community on the decisions made by an individual, so it was decided to examine the variation in certain aspects of wheat farming between one village and the next, as a measure of the village identity of the farmer.

Soil and climatic conditions did not vary significantly between the villages (pp480-1), but when human variables were examined, a significant difference was found to exist between villages, with respect to the major caste groups (chi square = 102.45, significant at .1 per cent level of probability). This significant link between the caste and the village identity of the farmer makes the evaluation of any relationship between either caste or village identity and a 'dependent' variable, difficult. The proportion of the relationship which is the result of direct influence from one independent variable and the proportion due to indirect influence from the second independent via the first, cannot be estimated easily. Such are the problems of interpreting data where the independent variables are co-linear.

The year in which farmers received instruction seemed likely to be affected by the variable 'village identity of the farmer'. Cultivators who lived in villages nearer the district centre were more likely to receive instruction in the new farming technology earlier than other villagers. Many farmers had received no information at all, and a chi square test was used to compare the proportion of farmers in each village who had received instruction in new farming techniques since 1965. A highly significant difference was found to exist, (chi square = 59.82, significant at .1 per cent level), and out of 61 per cent of the farmers who had been instructed in the new techniques, 70 per cent were from the tube well villages of Akhtiarpur, Manakpur and Chirchita, and the chi square test confirmed that they had received instruction significantly earlier than had

farmers from the canal villages. (chi square = 28.63, significant at .1 per cent level). The reasons for this bias were examined in Chapter 4. p.153 . At present it is sufficient to establish that a significant link does exist between the two variables 'village identity' and 'the year of instruction', the former being the variable which exerts the greater influence.

Some individuals of a particular village community were observed to own and manage larger than average farms, and it could be argued that the nature of the village community could affect the size of the area farmed. For example, a village community composed of socially important individuals may have the ability to acquire larger areas of land, despite legislation to the contrary. The size of farm can directly affect profitability per hectare, and access to such resources could be a major influence on cultivator decision, and hence be reflected through the village identity of the farmer. When analysed by the chi square test, there was no significant difference between the sizes of the farms in the six study villages, and so it did not appear that the village identity of the farmer and the size of the area he farmed, were significantly related.

Chi square tests were also used to show that the variables of 'education' and 'village identity' were not significantly related, and any apparent links could be the result of chance.

During the field work it was always clear that former zamindars were the more privileged members of the farming society. Although cases could be identified where this was not so, it was

more the rule than the exception that ex-zamindars were of higher social status. A question was included in the questionnaire, which was intended to determine whether or not the farmer was a former zamindar or was closely related to one. Unfortunately the sample contained no ex-zamindars or close relatives. Questions relating to tenurial status were of little value, as after the act of 'zamindari abolition' in 1952¹, all tenant farmers automatically became land owners, and even in 1972, any tenant who farms an area of land for more than two years, assumes ownership. This act was passed to make the ownership of land more equitable, and although it left the zamindars still in privileged positions, the extent of the inequalities which existed before zamindari abolition were much reduced.

-
1. After Indian independence positive moves were made towards a re-structuring of the land tenurial system. In 1950, the U.P. Legislative Assembly passed the U.P. Zamindari and Land Reform Act. The law went into effect in 1952. The occupancy tenants became owners of the land they were cultivating, and continued paying tax to the State, equivalent to the rent levied by the zamindars. As compensation, the zamindars received in cash eight times the net annual revenue from the lands on which they were losing their rights, and paid only half the tax previously levied.

Source: Etienne, G. Indian Agriculture, the Art of the Possible. 1968, California, pp.58-59.

4. Caste of the farmer.

The caste of an individual frequently assumes a prominent position in the explanation of relationships. Although its effects were often refuted during discussions in the field, its potential influence on the other variables both 'independent' and dependent, seemed marked. The number of representatives within each of the enumerated castes was inadequate for statistical analysis, so the castes were arbitrarily organised into three groups suggested by local officials.

| | | |
|-------------|------|-----------------------------------|
| Caste group | I. | Jats, Brahmins, Rajputs. |
| | II. | Lodhas, Gujars. |
| | III. | Chamars, Muslims, Muslim-Rajputs. |
| | IV. | Other Hindus, Shepherds. |

Reading Fig.A.8 from the left, we see that if farming was influenced by caste, then the independent variable, soil, could not be linked directly, but it could be affected via the set of dependent variables. In reverse, soil conditions are unlikely to influence the caste of a farmer.

The village identity - caste relationship has been considered and emergent relationships have been fully discussed in the preceding paragraphs (Section 3).

The caste - education relationship is interesting as both these variables seem to affect the group of dependent variables. Education level was divided into three groups: those farmers who had had no education, those who had received a primary education and those who had been educated above primary level.

A very strong relationship exists between caste and education as shown by the highly significant results from the chi square tests (Chi square = 49.15, significant at .1 per cent level). These results are very probably not due to chance. The higher caste of Jats, Brahmins and Rajputs contain all the highly educated groups. The Gujars and the Lodhas are less well educated, but some have been to primary schools. Most of the farmers of caste group III, the Chamars, Muslims and Muslim-Rajputs, however do not seem to have had any education at all. As there is such a close relationship between the three education and three main caste groups, it is meaningless to refer to these variables as 'independent'. However, for the purpose of the statistical tests these must remain so. The caste - education relationship can only be a one way process, in which caste influences education; the opposite can not be true. If a strong relationship is found to exist between some or all of the dependents and education, regardless of statistical significance, it can be argued that it is caste acting via education that is the main 'causative' variable.

Caste did appear to be linked to the year cultivators received instruction in the new farming technology. The chi square test did not show any significant difference between the proportions of the major caste groups who had received information, but the analysis in Chapter 4, pp. 152-5 (Fig. 4.6) does make it clear that the 'higher' castes of group I received instruction significantly earlier than did cultivators belonging to caste groups II and III. Caste could have a direct effect on the year of instruction in the new technology, but the apparent relationship could also be due to the indirect effect of the variable 'village

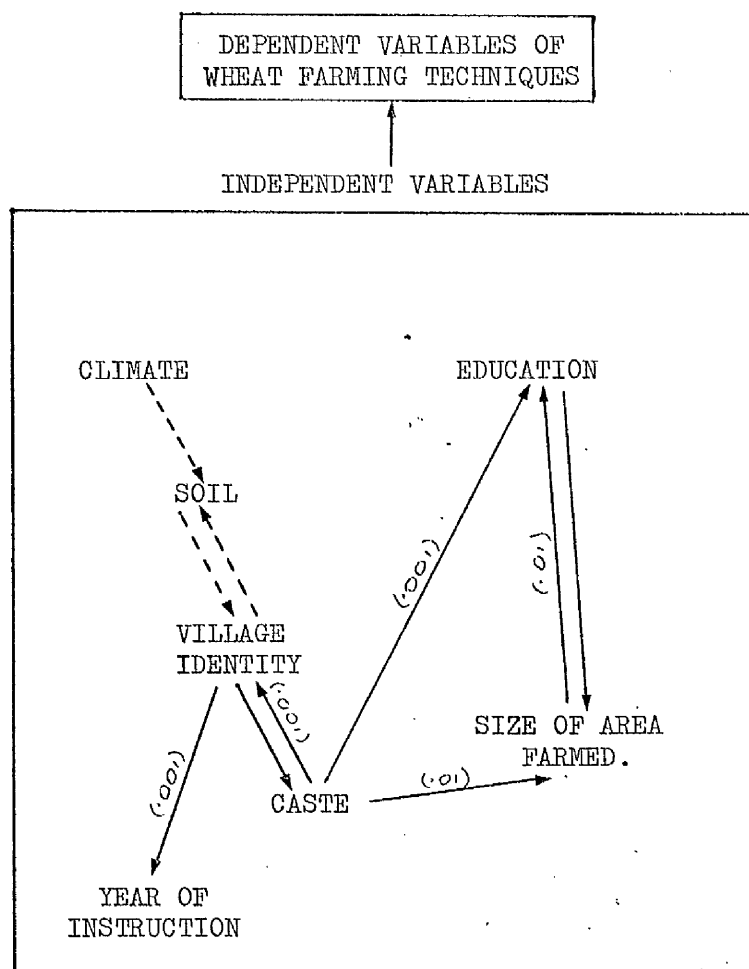
identity'. Either way, the year of instruction was unlikely to influence the caste of the farmer, so the relationship functioned in one direction only.

Caste also shows a strong positive relationship with farm size (chi square = 10.02, significant at 1.0 per cent level). The link between these two variables is not as strong as in the caste - education case. It is still considered worth while to use the variable of size of area farmed as a statistically independent variable, but owing to its linkages with caste, all direct relationships in which it is involved will be treated with reservation. Any such positive relationship might indicate that the size of the area farmed has a causal effect on certain decisions made by the farmer. This could never be certain as caste may well have a direct effect on farm size and so, any relationship in which farm size is the 'independent' and hence, causative variable, may be indirectly controlled by caste rather than directly by farm size.

5. Size of the area farmed.

The relationship between the size of the area farmed and caste has just been discussed, but apart from caste where a one way relationship appears to exist, a two way link could be hypothesized between size of the area farmed and education. From observation farmers who cultivated holdings above the sample mean of 3.54 hectares did appear to be the more progressive members of the community, and this could be because they were better educated. A chi square test showed that there was a significant degree of relationship between these two variables,

Diagram to show the relationships between potentially causative ('independent') variables.



- Direction of relationship.
- Strength of relationship not assessed.
- (.001) Level of significance of relationship.

Fig.A.8.

(chi square = 25.14, significant at 1.0 per cent level), but as caste directly affects education, it is likely that the education - farm size relationship is largely explained by caste acting indirectly through education and farm size. The village identity - farm size relationship has also been analysed. The village could have a direct influence on farm size, or yet again, caste could be exerting its influence on it through the village. However, the chi square test showed that a significant relationship did not exist between these two variables, and so any indirect influence of caste via the village identity could be due to chance (Fig.A.8).

No significant link was evident between the size of the area farmed and the year of instruction of the farmer. Any chance relationship seemed most likely to be the indirect effect of the variable, village identity. The relationship between these two variables has been examined in Section 3.

Unfortunately non-parametric multi-variate techniques cannot be used in this case to explain the proportion of overlap between these variables, as the nominal scale used for some variables excludes the use of such techniques. Fig.A.8 summarizes the significant linkages which have emerged from this analysis of the so called 'independent' variables. The direction of the relationships was decided on the basis of field observation. In any set of relationships involving human decisions, it is unlikely that the influence of any single variable can be isolated and quantified in absolute terms. It is not possible in this case, but as the group of 'independent' variables shown on p.66

are likely to exercise some direct and indirect influence, they have all been used in the analysis of the variation in the group of dependent variables in this thesis.

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